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THE SCIENTIFIC MONTHLY

MAY, 1927

DID MAN ORIGINATE IN CENTRAL ASIA?

(MONGOLIA THE NEW WORLD, PART V)

By Professor WILLIAM K. GREGORY

AMERICAN MUSEUM OF NATURAL HISTORY

DR. WILLIAM DILLER MATTHEW¹ and Professor Henry Fairfield Osborn² have long been the major prophets of the Dawn Man in Central Asia. Dr. Roy C. Andrews has sought him there with much labor but in vain. It has remained for Drs. J. G. Andersson and O. Zdansky to put the Dawn Man firmly on the map of China.

In an ancient cave at Chou Kou Tien, southwest of Peking, Dr. Andersson, of the Geological Survey of China, in 1921 discovered a rich fossiliferous deposit, which was later surveyed, partially excavated and described by Dr. Zdansky, of the University of Upsala. In addition to fossil teeth and bones of various mammals found there, including bats and monkeys, there were "two specimens of extraordinary interest, namely, one premolar and one molar tooth of a species which cannot otherwise be named than *Homo? sp.*"³ "One of the teeth recovered," Dr. Black states, "is a right upper molar, probably the third, whose relatively unworn crown presents characters which appear from the photographs to be essentially human. . . .

The other tooth is probably a lower anterior premolar," the crown of which is "practically unworn and appears in the photograph to be essentially bicuspid in character, a condition usually to be correlated with a reduction of the upper canine." As to the age of the deposit and of the embedded human teeth, Drs. Andersson and Zdansky consider that the Chou Kou Tien fauna was possibly of Upper Pliocene age, but Dr. Black notes that in the light of recent research it is possible that the horizon represented by this site may be of Lower Pleistocene age. "Whether it be of late Tertiary or of early Quaternary age, the outstanding fact remains that for the first time on the Asiatic continent north of the Himalayas, archaic hominid fossil material has been recovered, accompanied by complete and certain geological data. The actual presence of early man in eastern Asia is therefore now no longer a matter of conjecture."

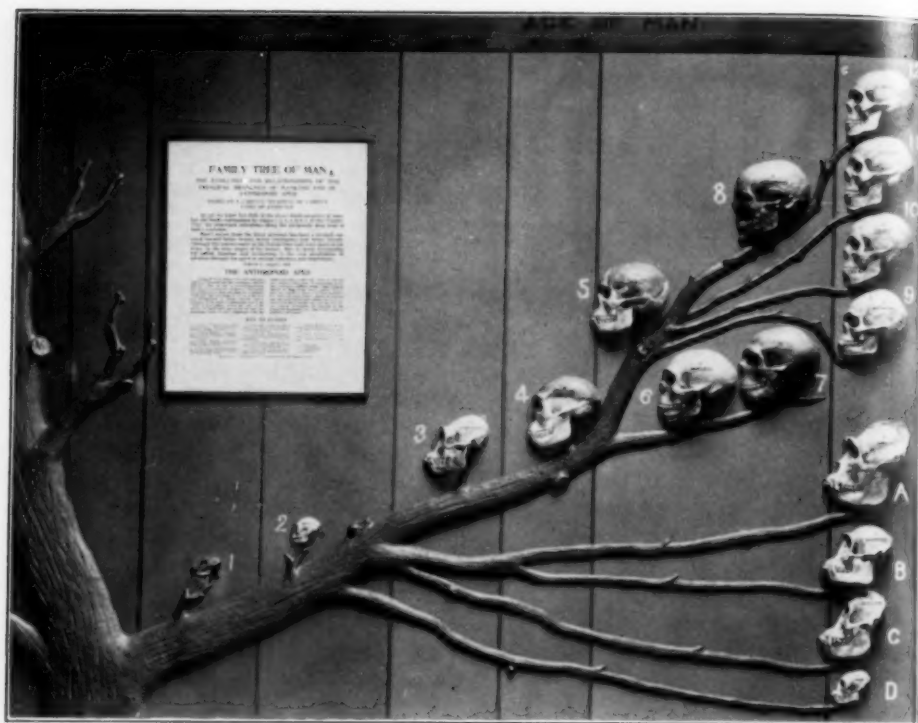
Dr. Black further notes that the Chou Kou Tien molar would seem to resemble in general features a certain fossil molar tooth described in 1903 by the eminent German paleontologist, Max Schlosser, which tooth had been purchased in a Peking drug store.⁴ From the nature of its fossilization Schlosser considered the

¹ "Climate and Evolution," Ann. N. Y. Acad. Sci., 1915, XXIV, pp. 209-214.

² In various articles in *Asia and Natural History*.

³ Black, Davidson, "Tertiary Man in Asia: The Chou Kou Tien Discovery," *Science*, Vol. LXIV, Nov. 17, 1926, pp. 586, 587.

⁴ The Chinese use ground-up fossil "dragon bones" as medicine.



THE ASCENT OF MAN FROM LOWER PRIMATES, AS INFERRED
BY WILLIAM K. GREGORY, 1924

Key to Stages

1. PRIMITIVE PRIMATE (*Notharctus osborni*). FOSSIL SKULL AND JAW, SLIGHTLY RECONSTRUCTED, OF EOCENE AGE, WYOMING. ORIGINAL IN AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.
 2. PROTOTYPAL ANTHROPOID. RECONSTRUCTION BASED ON FOSSIL JAW (*Propliopithecus haeckeli*) OF OLIGOCENE AGE, EGYPT. ORIGINAL JAW IN STUTTGART MUSEUM, GERMANY.
 3. PRIMITIVE ANTHROPOID, *Dryopithecus* sp. RECONSTRUCTION. PLACED HERE AS A REPRESENTATIVE OF A WIDE RANGE OF SPECIES, SOME OF WHICH ARE PROBABLY NEARER TO THE HUMAN BRANCH AND OTHERS TO THE VARIOUS ANTHROPOIDS.
 4. TRINIT APE-MAN. RECONSTRUCTION BASED ON FOSSIL SKULL-TOP (*Pithecanthropus erectus*), OF UPPER PLIOCENE OR (MORE PROBABLY) LOWER PLEISTOCENE AGE, JAVA. ORIGINAL IN TEYLER MUSEUM, HAARLEM, HOLLAND.
 5. PILTDOWN MAN. RECONSTRUCTION BASED ON FOSSIL SKULL AND LOWER JAW (*Eoanthropus dawsoni*), OF PLEISTOCENE AGE, ENGLAND. ORIGINAL IN BRITISH MUSEUM (NATURAL HISTORY), LONDON.
 6. HEIDELBERG MAN. RECONSTRUCTION BASED ON FOSSIL JAW (*Homo heidelbergensis*), OF LOWER PLEISTOCENE, GERMANY. ORIGINAL IN UNIVERSITY OF HEIDELBERG, GERMANY.
 7. NEANDERTHAL MAN. FOSSIL SKULL AND JAW, SLIGHTLY RESTORED, OF THE OLD STONE AGE, EUROPE. ORIGINALS IN PARIS MUSEUM OF NATURAL HISTORY.
 8. CRO-MAGNON MAN. FOSSIL SKULL AND JAW, SLIGHTLY RESTORED, OF LATE PALEOLITHIC AGE, FRANCE. ORIGINALS IN PARIS MUSEUM.
 9. AUSTRALIAN ABORIGINAL. ONE OF THE MOST PRIMITIVE OF EXISTING HUMAN RACES.
 10. HOTTENTOT. REPRESENTING THE NEGROID GROUP OF RACES.
 11. CHINESE. REPRESENTING THE MONGOLIAN GROUP.
 12. AMERICAN. REPRESENTING THE CAUCASIAN GROUP.
- A. GORILLA, AFRICA. B. CHIMPANZEE, AFRICA. C. ORANG-UTAN, BORNEO. D. GIBBON, INDIA.
- RECONSTRUCTIONS NOS. 1, 3, BY OTTO FALKENBACH, UNDER DIRECTION OF WILLIAM K. GREGORY;
NO. 2, BY MARCELLE ROIGNEAU, UNDER DIRECTION OF J. H. MCGREGOR AND WILLIAM K. GREGORY;
NOS. 4, 5, 6, 7, 8, BY J. H. MCGREGOR.

specimen to be in all probability Tertiary in age, while from its detailed form he felt confident that it belonged either to a man or to a man-like anthropoid. He pointed out that future investigators might expect to find in China a new fossil anthropoid, Tertiary man or ancient Pleistocene man. "The Chou Kou Tien discovery thus constitutes a striking confirmation of that prediction" (Black).

Meanwhile Professor Osborn has on various occasions and with much force defended Reid Moir's claims for the human manufacture of certain types of apparently worked flints found embedded in strata of Pliocene age along the coast of Sussex, England. This, if confirmed by further evidence, dwarfs earlier ideas of the vast extent of man's antiquity. Herodotus says in substance that an aged Egyptian priest told Solon that the Greeks had hardly an inkling of real antiquity, that their ideas of ancient times were slight indeed compared with the records of hoary antiquity known to the priests of Egypt. But what were these records, what were even the mythological dynasties of the Hindus, extending into tens of thousands of years, compared with the antiquity of the Heidelberg man from the first Interglacial period of Europe, a matter of several hundreds of thousands of years? And what is that, in turn, compared with the antiquity of Pliocene man, which may be a million years or more?

To some it may seem almost sacrilegious to belittle thus the antiquity of the ancient temples of Asia. And what does late Pliocene or early Pleistocene man of China do to the traditional Eden in Mesopotamia of 4000 B. C.? On the other hand, do not such facts, if confirmed, bring ruin on the orthodox scientific theory of the origin of man from the stem of the anthropoid apes? Will they not indeed strongly support Professor Osborn, who in various publications

prophesies the discovery of the remote ancestors of man in Central Asia, in formations of Oligocene or even Eocene age, and who, with the confidence born of a half century of brilliant paleontologic researches, also predicts that these ancestors will be found to be, not "ape-men," but already upright-walking, large-brained Dawn Men of the plains?

Before attempting to answer these questions, let us consider first the great expansion of the idea of the earth's antiquity that has come even to geologists, accustomed as they were to figures of inconceivable magnitude.

A couple of generations ago scientific estimates of the age of the earth and of the length of time represented by the rocks of any of the geologic periods were perhaps as inadequate as the Greek conception of human antiquity. The entire age of the earth was reckoned at less than a hundred million years, and the time from the beginning of the Tertiary period (the Eocene epoch) was estimated as a scant three million years. The most widely accepted of these estimates (by the eminent geologists Dana and Walcott) were based on the division of the known average rate at which the great river systems of the world are now carrying off their upland drainage basins and laying down deposits along the shores of the continents, into the total thickness of sedimentary rocks in the geologic column. But then came a succession of investigations and discoveries indicating that the present rate at which rocks are being formed is far too high to be taken as an average figure and that, on various accounts, the geologic column as a whole is vastly longer than it was supposed to be. The astronomers and geophysicists also were dissatisfied with the one hundred million years computed as the probable age of the earth by Lord Kelvin. These calculations were based on the theory of a slowly cooling earth but, from the researches of

Becquerel, Rutherford, Boltwood, Barrell⁵ and others on radioactive minerals, there emerged the method of estimating the age in years of uranium and thorium ores, since the times of their crystallization from molten rock intruded between known geologic horizons. It was found that uranium gives off α , β and γ -rays at a constant rate and that it tends to disintegrate or transform from uranium, through several intermediate substances, including radium, into lead, the alpha rays being positively charged atoms of helium. It has also been found that the rate of disintegration of radium remains constant in spite of all efforts to modify it by subjecting it to temperatures up to 2500° C. and pressures up to 160 tons per square inch. It is deemed highly probable that the parent substance

⁵ "Rhythms and the Measurements of Geologic Time," Bull. Geol. Soc. Amer., 1917, Vol. 28, pp. 745-904.

uranium is equally unaffected by any changes that it would be likely to encounter near the surface of the earth, so that its accuracy as a chronometer is relatively high. An atom of uranium which breaks up will ultimately give rise as stable products to eight atoms of helium and one of lead. In an unaltered dense crystalline rock the lead and helium also remain unaltered. It is estimated that a given quantity of uranium will disintegrate to half the original amount in six billion years.⁶ The ratio of the weight of the helium and lead to the weight of the uranium in the sample will give the main basis for computing the age of the rock in years.

The late Professor Joseph Barrell, of Yale University, applying the results of

⁶ J. Harlen Bretz, in "The Nature of the World and of Man." Univ. Chicago Press, 1926, p. 83.



Photograph by American Museum of Natural History

TSERIN, THE MONGOL GUIDE AND HUNTER OF THE EXPEDITION,
IN THE DUNES AT TSAGAN NOR.



Photograph by American Museum of Natural History

MERIN THE CAMEL LEADER

LEADING THE CARAVAN ACROSS THE DUNES OF TSAGAN NOR IN SEARCH OF WATER.

the "radium method" to rocks from various horizons in the geologic column, estimated that the oldest Precambrian granites measured were intruded 1,400,000,000 years ago and that the beginning of the Tertiary period (the Eocene epoch) would have to be set down as about sixty millions of years ago.

It is not to be supposed that geologists regard the figures arrived at from the "radium emanation" method as indicating much more than the general orders of magnitude of the successive ages. The estimates based on thorium ores are somewhat different from those based on uranium ores and all the estimates based on radium emanations are far greater than those obtained through any of the other methods of estimating geologic time. Nevertheless, the doubtful factors in the equations can perhaps never bring the estimates down to the

seant figures obtained by Lord Kelvin and his immediate successors, and even the epochs of the Tertiary period may each represent millions of years, instead of hundreds of thousands, as formerly supposed. The Pliocene epoch in recent estimates is credited with a duration of six million years! Hence if man existed as such in the Middle Pliocene, as claimed upon strong evidence by Professor Osborn, his antiquity becomes inconceivably vast.

Our conceptions of the magnitude and wonder of nature have also had to expand in another direction. A "genealogical tree," representing, for instance, the evolution of mastodons and elephants during the Tertiary period, used to be conceived as a comparatively simple affair with a moderate number of branches and stems and a large but still comprehensible number of twigs and



Photograph by American Museum of Natural History

MR. NELSON MAKING THE PRELIMINARY CLASSIFICATION
ACCORDING TO FORM

leaves. Moreover, the branches and twigs used to be represented in the diagrams as moving rather rapidly apart from each other and still must be so drawn, if the diagram is to be fitted on a single page. But many paleontological discoveries have proved that modern animals, such as the bear, cat, dog, horse, elephant, cow, pig, represent whole clusters of lines that have been separate from each other for enormous periods of time. Some of the horses of Pliocene times, for instance, were very little different in structural details from their existing relatives and descendants, the horses, asses and zebras. The Pliocene bears were already established in North America and but slightly different from some of their modern descendants. Again, many of the rodents have changed but very little in the same interval. Such discoveries as these have been made so often that not a few vertebrate paleontologists have been much more active in demolishing the "genealogical trees" set up by their predecessors than in working out new ones for

themselves. It has become the fashion to exclude almost every known earlier form from ancestral relationship to every known later form. The "trees" have been broken up into nearly parallel lines, converging, if at all, only at infinity. On the side of classification, species are being promoted to genera, genera are raised to subfamilies, subfamilies to families, families to suborders, suborders to orders. Finally, in the case of fishes there is a well-marked tendency on the part of some authors to disregard the ordinal divisions and to present almost interminable lists of families, species and genera unrelieved by larger groups. Thus the ruins of the classifications of the elders seem at first sight to be deeply buried in masses of details.

However, leaving out of account for the moment the possibility that these tendencies and viewpoints may represent an extreme swing of the pendulum of human thought in a certain direction, and that the reaction may be even now under way, it is not the nature of science to remain long buried in its own ruins:

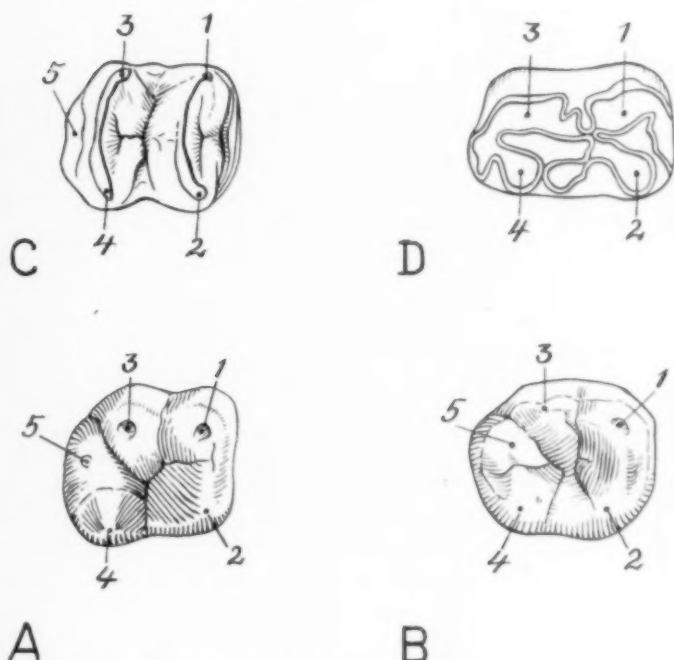


FIG. 1. MAN AND ANTHROPOID MORE NEARLY RELATED IN TOOTH STRUCTURE THAN HORSE AND TAPIR

A, B. LOWER MOLAR TOOTH OF FOSSIL *Dryopithecus* (A) AND EHRLINGSDOF MAN (B).

C, D. LOWER MOLAR TOOTH OF TAPIR (C) AND HORSE (D).

there is, in fact, distinctly another side to the story. Both geologic epochs and independent lines of mammalian descent are doubtless far more extended in geologic time than was suspected in the time of Huxley. But if, on the one hand, the individual epochs and the phylogenetic histories have lengthened, so, on the other hand, has the record lengthened as a whole, and consequently the *relative* lengths of the different epochs remain much as they were before. At first sight, Pliocene man may seem to us a being of inconceivable antiquity, but even if, according to the latest estimate, he existed as man more than a million years ago, he was even then many times nearer to us in time than he was to the beginnings of the primate stem in the Basal Eocene some sixty million years ago.

It may be true, as Professor Osborn implies, that the real ancestral home of the human family is as far back of the Pliocene epoch as that is back of the mythical Adam in the Mesopotamian paradise, so that proud mortals may comfort themselves in the thought that for millions of years they have belonged to a "superior" family of primate mammals. And by as much as geological time lengthens before us, by so much increases the apparent power of heredity to resist the pressure of environment and selection and to keep the general pattern of all organisms nearly true to type, especially in the preservation of "living fossils," or conservative forms, through vast ages. But there is assuredly a fallacy lurking in the reasoning that because the horses and the elephants and many other mammals changed very

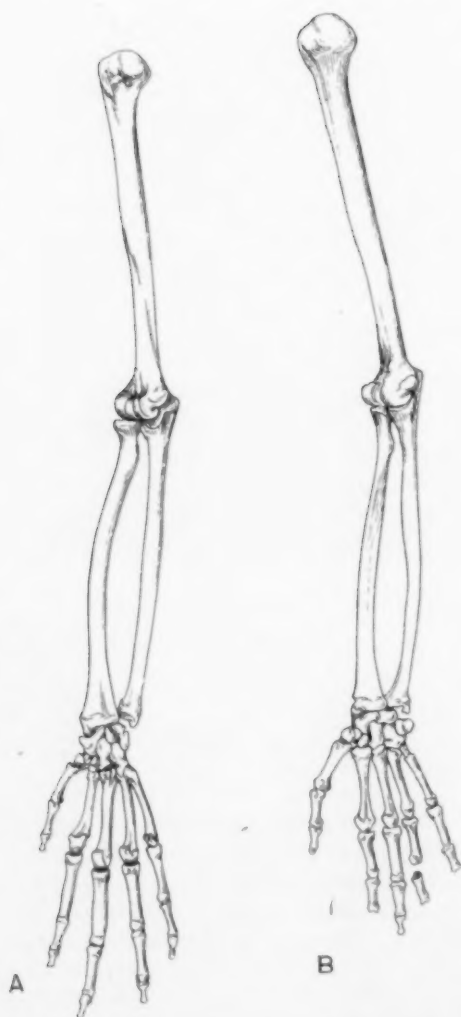


FIG. 2. ARM AND HAND OF CHIMPANZEE (A) AND VEDDAH (B)
AFTER FRITZ AND PAUL SARASIN.

slowly during the Pleistocene, Pliocene and Miocene, and because Pliocene man was (it is assumed) already man, therefore the human family was distinct from all others as far back as the families of horses, tapirs, etc., were distinct from each other, namely, as far back as the Oligocene or even the Eocene. The implied assumptions that the structural

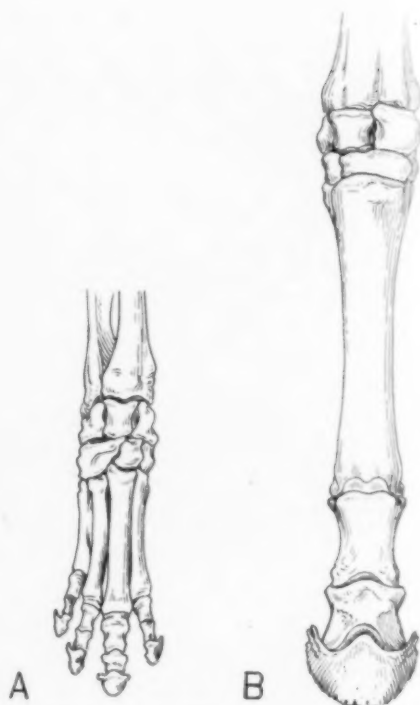


FIG. 3. HAND OF TAPIR (A)
AND HORSE (B)

evolution of man has proceeded at a constant, if almost infinitesimal rate, and that this rate is roughly the same as in the horses, tapirs, elephants, etc., not only lacks positive evidence but is certainly not in harmony with a great body of well-tested evidence from many sources.

In the case of the modern horses, tapirs and rhinoceroses—very diverse animals whose Lower Eocene ancestors were but slightly different from each other—nothing of the kind is better evidenced than the fact that structural evolution has proceeded at very different rates in the different families. The tapirs, for instance, after the lapse of all the millions of years since the Lower Eocene still retain many characters in the feet, limbs, backbone and low-crowned grinding teeth, which are in-

herited from the very remote common ancestors of horses, tapirs and rhinoceroses, while during the same time the horses have undergone far more radical changes and retained correspondingly fewer primitive characters in these structures. Obviously, if rates of evolution were uniform in all descendants of a common stock there could indeed be no science of comparative anatomy, because all animals of the present epoch would be in the same grade of organization and we should not find the conservatives, the progressives and the freaks living in the same epoch, as we frequently do. Moreover, it is widely recognized that in a given evolutionary series certain structures, such as the teeth or the feet, may undergo far greater changes in a given period than other parts, such as the reproductive system, whereas in other series the teeth may be relatively conservative, even degenerative, while the brain may undergo great changes, as in the toothed whales.

The very existence of many independent, slowly divergent phyletic lines within each given family of the titanotheres, horses and rhinoceroses—all distinguished by quantitative or proportional differences in their several parts—as so abundantly documented by Professor Osborn in America and by Depéret, Stehlin and others in Europe, affords definite evidence for the statement that during a given period rates of evolution are not uniform, even in allied series, and this is true whether we are considering special parts, such as the molar teeth, the feet, the brain or the total amount of evolution in the skeleton as a whole, as when we compare the skeletons of the modern tapir and of the horse with that of the primitive *Eohippus* of the Lower Eocene. Hence we are by no means warranted in assuming that because the common ancestors of other divergent families are to be sought at least not later than in the Lower Eocene,

the same will prove true of the human family and of its nearest relatives among the other primates.

Even if it be fully proved in the future that all Pliocene men were as nearly like modern men as the most progressive of the Pliocene horses were like modern horses, it by no means follows that modern man is as far removed in relationship from the chimpanzee as the horse is from the tapir (Figs. 1-3). To the extent that degrees of structural resemblance or difference may correspond with degrees of genetic relationship we may affirm that on the whole man is much nearer to the chimpanzee and gorilla than the horse is to the tapir (Figs. 1, 2). In fact, in one of Professor Osborn's "Pliocene Dawn-Men" (*Eoanthropus*) the lower molar teeth so far as known are almost generically indistinguishable from those of the Pliocene anthropoid *Dryopithecus* (Fig. 4), and the Pleistocene man, *Homo neanderthalensis*, retains in his lower and upper molars the clearest evidence of his proto-anthropoid derivation, in spite of the wide divergence in foot structure of plains-dwelling man and forest-living ape (Fig. 5).

If we grant for the moment that the structural difference between two diverse members of a single group is roughly proportional to the time since they diverged from each other, then, as the structural difference between man and chimpanzee is on the whole far less than the difference between horse and tapir, so the time of separation between man and chimpanzee should be far less than the time of separation of horse and tapir. Therefore the lines of man and the chimpanzee should run together at a period far later than the Lower Eocene, which is the approximate time of separation of the lines leading to horse and tapir. If, on the other hand, man and the chimpanzee were on separate lines as far back as were the horse and the tapir (Lower

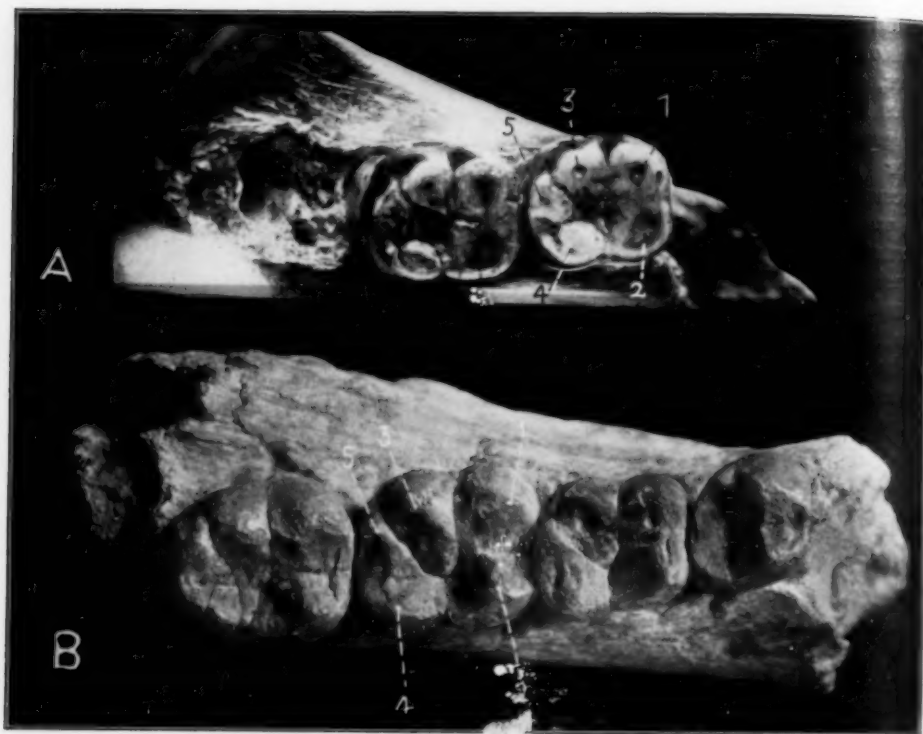


FIG. 4. LOWER MOLARS (LEFT) OF PILTDOWN HUMAN JAW (A) AND OF FOSSIL ANTHROPOID *DRYOPITHECUS FRICKAE* (B)

Eocene), then the rate of divergence must have been far slower between man and anthropoid than between horse and tapir. This again is an assumption contrary to present evidence from comparative anatomy, which indicates a remarkably high range of heritable variability and consequent instability, in both human and anthropoid stocks, as compared with the variabilities in tapirs and horses.

Sonntag's "Morphology and Evolution of the Apes and Man" and similar works record a large number of detailed anatomical differences between modern apes and man, differences which have doubtless accumulated during the millions of years during which the apes have become specialized for arboreal life and man for terrestrial life. But along

with these differences are hundreds of peculiar features common to man and his nearest relatives, the chimpanzee and the gorilla. Since the time of the great English anatomist Tyson (1699) it has been recognized that the chimpanzee in the totality of his anatomical characters stands far nearer to man than to the lowest existing primates. The laborious researches of students of the human brain, culminating in the recent work of Professor Tilney, reveal the most striking unity of plan in the basal architecture of the brains of gorilla and man. And when the evidence afforded by comparative embryology is sought, the relatively close kinship of man with the chimpanzee and gorilla becomes indubitably clear, as in the recent studies of



FIG. 5. FOOT OF ARBOREO-TERRESTRIAL GORILLAS AND TERRESTRIAL MAN
AFTER SCHULTZ

Professor Adolph H. Schultz, of Johns Hopkins University.

So many and deep-seated are the anatomical and physiological bonds between the anthropoid apes and man that Professor H. H. Wilder has proposed to recognize this relationship by referring the existing anthropoid apes and man to a single zoological family, the Homi-nidae. In other words, according to the viewpoint held by Wilder, Schvalbe, Keith, Elliot Smith, Sonntag, May, and many other recent investigators, including the present writer, the existing anthropoids and man are merely divergent branches of a primitive anthropoid stock, exactly as held by Darwin. To deny at this date or to seek to minimize the importance of man's close relationship with the chimpanzee-gorilla stock, is to shut one's eyes to a vast accumulation of well-tested facts. To attribute to parallelism the thousands of resemblances between man and chimpanzee is equivalent to saying that no zoological classification founded on deep-seated anatomical resemblance has any objective validity.

No matter how many millions of years ago man and the chimpanzee parted company, the anthropoid apes are still justly regarded as man's nearest relatives among existing mammals and the most intensive research has brought forth no adequate reason for doubting

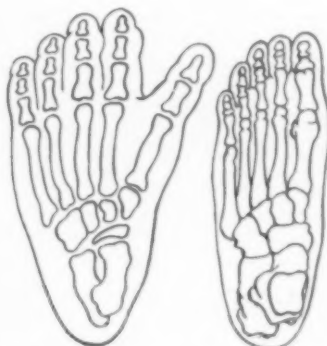


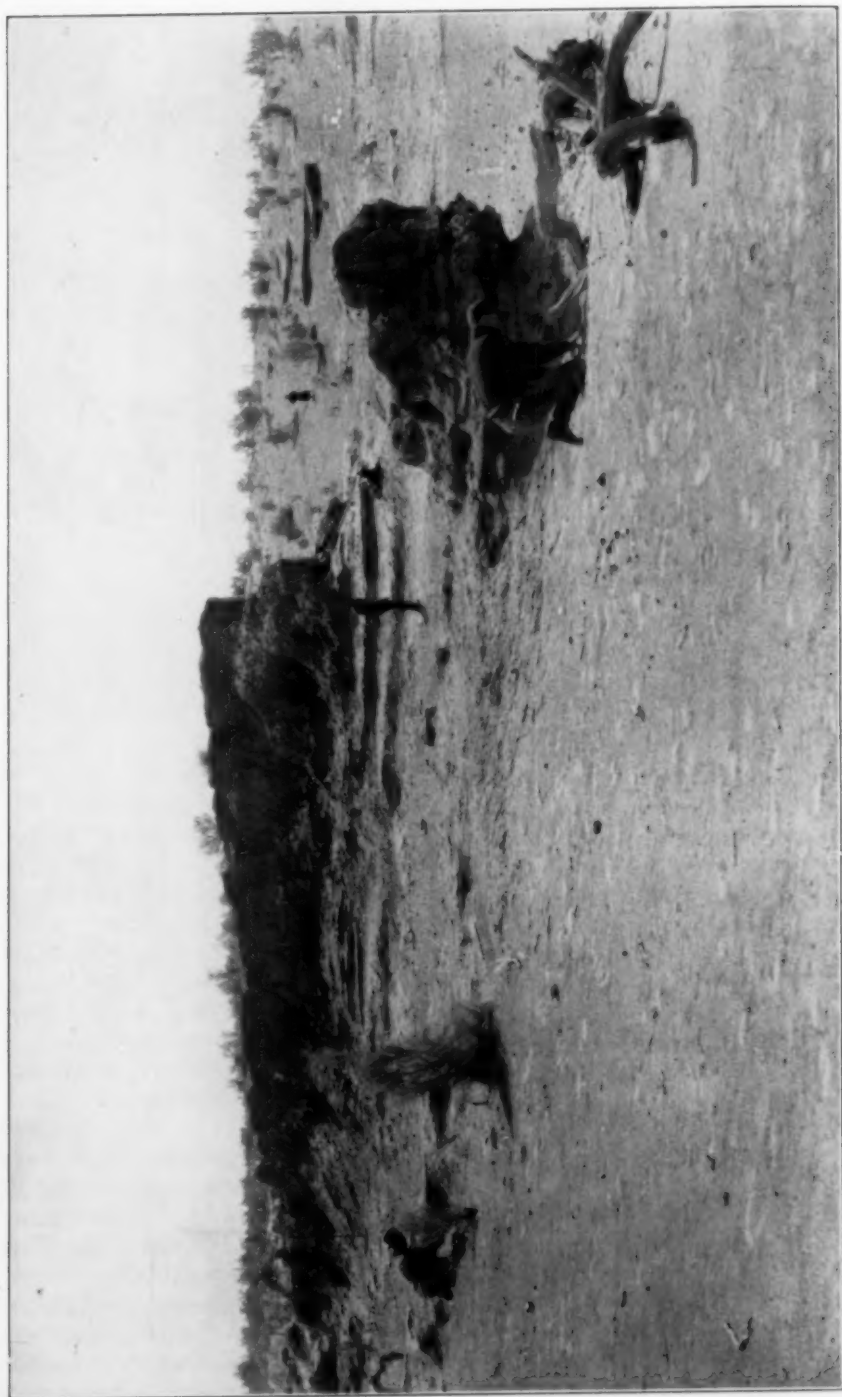
FIG. 6. DIAGRAM OF RADIOGRAPHS OF HUMAN FOOT

FETAL (NINTH WEEK, ENLARGED) AND ADULT HUMAN FOOT. AFTER SCHULTZ. IN THE EARLY FETAL STAGE THE FOOT IS PLAINLY SUGGESTIVE OF ANTHROPOID DERIVATION.

that man is an offshoot from the Old World Primates and in particular that he represents a highly modified offshoot of the anthropoid stem.

It is true that a few authors have failed to grasp this fundamental fact and that all sorts of queer theories have been promulgated, but at the present time the weight of a great many independent investigations is overwhelmingly in favor of the view that at one time man passed through an arboreal stage of life, not remaining there long enough to become over-specialized in that direction like the existing anthropoids, and that at a later period he came down out of the trees, preserving his erect arboreal posture and becoming a bipedal cursorial animal.

But what has all this to do with Mongolia and with the question whether man originated in Central Asia? In the first place, man, according to the view here defended, belongs in the Old World division of the higher Primates. Darwin with his usual sagacity grasped this fundamental truth and argued with force that we should not look to the New World series for the ancestry of man.



THE DUNES OF SHABARAKH USU
ANDREWS, NELSON AND YOUNG INVESTIGATING THE SITE WHERE THE DUNE DWELLERS CAMPED IN STONE AGE TIMES.
Photograph by American Museum of Natural History

The subsequent efforts of Ameghino and others to attach man to the platyrrhine or New World stem, have only brought out the soundness of Darwin's position. Up to the present time all the evidence from geographic distribution and from paleontology is in favor of the view that the "Old World" series arose somewhere in the eastern hemisphere. The oldest representatives of the Old World series so far known are found in the Lower Oligocene of Egypt as primitive forerunners of the anthropoid apes. The southeasterly outlying parts of the Eastern hemisphere, including New Guinea and Australia, are, so far as known, devoid of all traces of the anthropoid stock, except in so far as man reached there in relatively late times. As to North America, however early man may have reached there, *Hesperopithecus* of the Pliocene of western Nebraska, if it is an anthropoid, may well be an immigrant along with certain other mammals, from the presumed center of distribution in Asia.

Man is very definitely to be classified, according to his anatomic and physiologic characters, as an offshoot of the anthropoid stem. Where then is the ancestral home of that stock? At present the anthropoid apes are found from Borneo and Sumatra on the southeast to West Africa on the west, but in former ages representatives of the group at different times penetrated as far west as Spain and as far south as South Africa, with India as a definitely known area of anthropoid radiation in Upper Miocene and Lower Pliocene times.

According to the conclusions arrived at in the studies of Hellman and the present writer on the dentition of *Dryopithecus* and allied genera, the known fossil Indian anthropoids appear to be allied rather with the far eastern orangs than with the western division, which, according to our view, includes the gorilla, chimpanzee and man. In

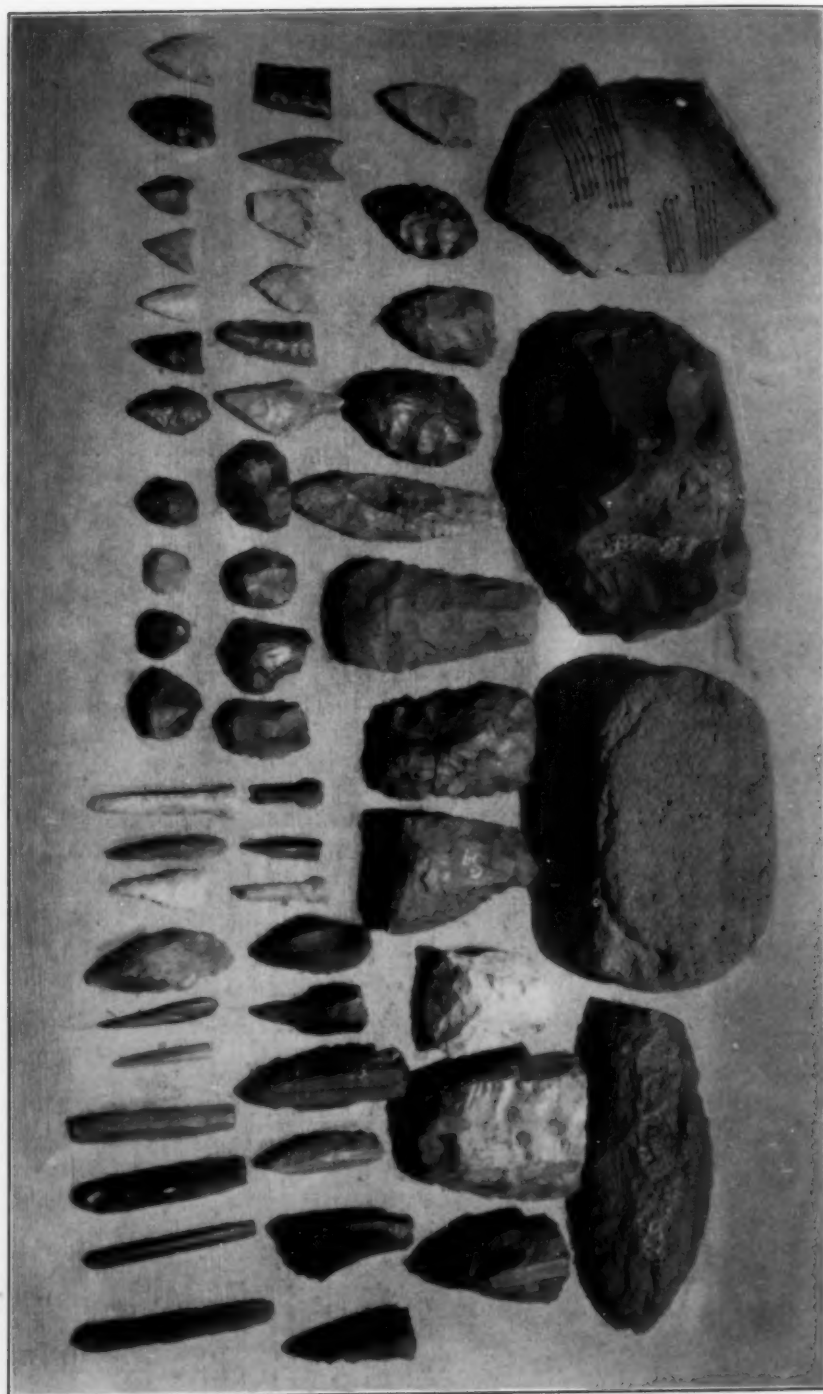
fact, as it appears to us, the nearest approach to human conditions is made by *Dryopithecus rhenanus* of the Pliocene of Europe, rather than by any of the Indian anthropoids and, as already stated, the lower molars of the Piltdown Dawn Man, so far as known, appear to be generically close to those of *Dryopithecus*.

But this does not necessarily indicate that the evolution of man took place in Europe, as Dr. Hrdlička⁷ holds. Europe, Asia and parts of Africa have been in more or less continuous contact for millions of years⁸ and it is a risky thing to argue that because Europe has yielded some of the most primitive known fossil men (Piltdown, Heidelberg, Ehringsdorf) and some of the most man-like apes (referred to *Dryopithecus rhenanus*) therefore the transition occurred in Europe, especially in view of the evident complexity of the migrations and counter-migrations of the fossil mammalian faunas between Asia, Europe and North America.

It is equally unwarranted to claim that because very ancient and primitive members of the man-anthropoid series have been found in the Lower Oligocene of Egypt, therefore Africa was the original center, inasmuch as the strictly geological record indicates that Egypt at that time was in broad contact with Southern Asia (Grabau and Black, *op. cit.*, pl. VI). Such claims should be allowed only after a careful and minute analysis of the geologic evidence tending to show what avenues of distribution may have been open, and after an

⁷ "The Peopling of the Earth," Proc. Amer. Philos. Soc., 1926, Vol. LXV, No. 3, pp. 150-156.

⁸ Compare the geological evidence summarized by Matthew, "Hypothetical Outlines of the Continents in Tertiary Times," Bull. Amer. Mus. Nat. Hist., Vol. XXII, pp. 353-383, and by Grabau (in Black, Davidson, "Asia and the Dispersal of the Primates," Bull. Geol. Soc. China, 1925, Vol. IV, No. 2, pp. 133-183).



Photograph by American Museum of Natural History
 EXAMPLES OF POTTERY AND VARIOUS TYPES OF ARTIFACTS MADE BY THE DUNE DWELLERS OF THE GULF

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equally thorough comparison of the given fauna and of its elements with those of earlier and later faunas elsewhere. Such an analysis has been made by Professor Dart of the conditions under which lived the most man-like anthropoid, *Australopithecus*, of South Africa. But it may be suspected that *Australopithecus* represents the extreme southward thrust of the chimpanzee stock after it had separated from man.

The existence of *Pithecanthropus* and the primitive Wadjak and Australian human skulls at points far to the southeast of the Asiatic uplands is consistent with the view that the center of dispersal of the human series was in some relatively central region. Finally the recent discovery of ancient man (of Pleistocene or Pliocene age) in China tells strongly in the same direction.

The Central Asiatic expedition should therefore be encouraged to search with all zeal for evidence of the origin of man in Oligocene and Eocene formations of Mongolia, but the members of the expedition should not be downhearted if no such traces be found at that very low horizon.

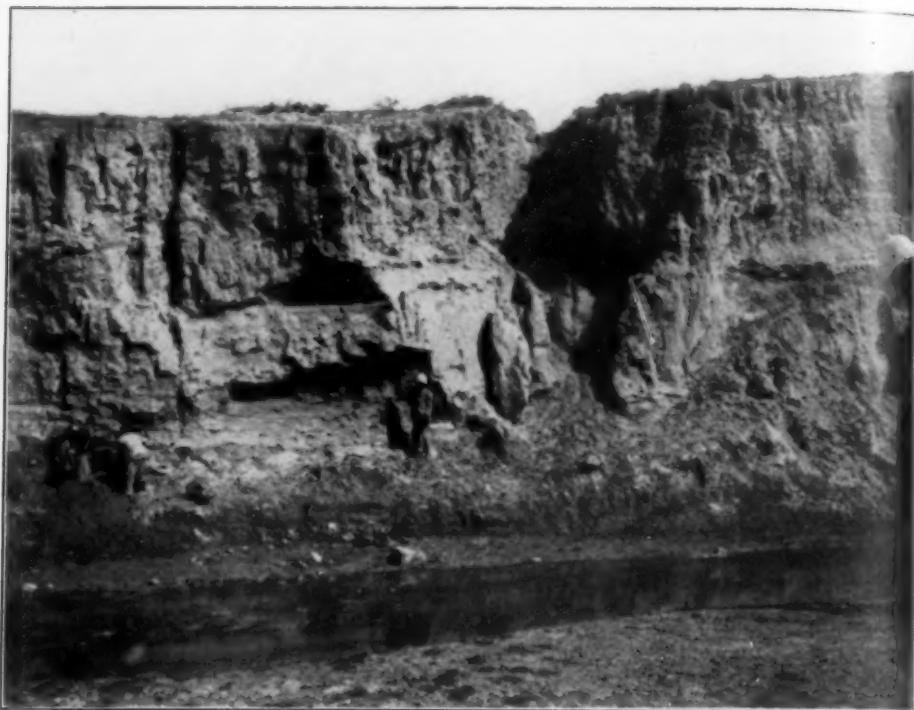
Dr. Black's masterly synthesis of geologic, paleontologic and anthropologic data leads him to conclude (pp. 174-179) that the differentiation of the human from the proto-anthropoid stock took place in correlation with the slow but progressive elevation and desiccation of the vast Central Asiatic region. During the Eocene the land was low and covered with semitropical rain forest; during the Oligocene the rise of the Himalayas was a time of great forests like those of parts of modern Ceylon. In Miocene time forests of more northern character interspersed with open stretches of savannah became prevalent, till before its final elevation in the Pleistocene the region became one of open plains and restricted wooded areas. Meantime, Dr. Black points out, these

changes in the environment would tend to increase, if they did not initiate, the cleavage between the proto-human and the (modern) great anthropoid stocks. The latter, a conservative group, were characterized by relatively early maturity of growth and inability to become modified with the changing environment. They therefore tended to migrate along with their own kind of environment and scattered remnants of the great forested areas. The second or progressive group early developed a tendency toward a prolonged period of childhood, resulting in a retarded maturation of the skull and great relative and absolute increase in the volume of the cerebrum. By reason of the resulting increase in mental capacity this group became increasingly adaptable to the change from forest to open country and gave rise near the center of its origin to group after group of successively higher types; the older, more archaic types being pushed away to the periphery, in accordance with the principle developed by W. D. Matthew.

Finally, Dr. Black, from geologic data assembled by Grabau, points the way to future exploration in the Yung Ling range of the Tibetan Alps as the most likely region in which to search for remains of the more conservative group, while he looks to the Tertiary deposits of the Tarim region to the north of Tibet for possible traces of early members of the plains-living proto-humanoid and early human stock.

Meanwhile considerable progress has already been made toward discovering the sequence of early human cultures in China and Mongolia. Père Licent, director of the Tientsin Museum, and Père Teilhard de Chardin,⁹ of the Paris Museum of Natural History, in 1923 discovered at Choei-tong-k'ou in the vicinity of Ordos, in the great bend of the Hoang-ho river, a great quantity of

⁹ "Fossil Man in China and Mongolia," *Natural History*, May-June, Vol. 26, p. 238.



Photograph by courtesy of Père Teilhard de Chardin

PALEOLITHIC BEDS OF CHOEI-TONG-K'EOU

AT THE TIME OF DISCOVERY. THE "HEARTH" BEGINS AT THE POINT WHERE THE MAN AT THE RIGHT TOUCHES THE CLIFF.

coarse implements of quartzite-worked flakes or blades similar to the Moustèrian and Aurignacian implements of Europe, and small flint implements of much finer type. These were found in "hearth" sites buried under at least fifty feet of loess formation, and show that man inhabited this site at the commencement of the formation of the loess. Bones of the kiang, aurochs, argali sheep, gazelle, woolly rhinoceros, hyena and ostrich were found on the same hearths. In other localities of this region Pères Licent and Teilhard found traces of Paleolithic man at a depth of some 180 feet below the actual level of the steppe. Père Teilhard concludes that the discovery of worked quartzites in gravels at the base of the loess at

Sjara-osso-gol, proves "that Paleolithic man lived in China not only during the formation of the loess but from its very beginning and perhaps even earlier. Thus man has seen China without its mantle of Yellow Earth, which gives us a vivid realization of his antiquity in the Far East. Great as it is, however, this antiquity is as yet less than the known antiquity of man in the West. The loess, as we have said, seems to correspond to the latest stages of the Glacial Epoch in Europe and North America. If this is true, then man of the Yellow Earth is far more recent than, for instance, man of the gravels of Chelles and Saint Acheul."

From later ages, including Mesolithic, Neolithic and pre-Mongol horizons, Dr.

Nels C. Nelson,¹⁰ of Dr. Andrews' expedition, has collected a large series of flint implements and other cultural remains in different localities in Mongolia

¹⁰ "The Dune Dwellers of the Gobi," *Natural History*, May-June, 1926, Vol. 26, p. 246.

and China. In this way the very remote past of man in these countries is gradually being tied in with later history, the geologists and archeologists together tracing the rhythmic alternation of more arid and more humid climates and their effects upon the human populations.



Chardin

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THE SESQUICENTENNIAL OF THE BIRTH OF GAUSS

By G. WALDO DUNNINGTON

WASHINGTON AND LEE UNIVERSITY

ON April 30, 1927, fell the one hundred and fiftieth anniversary of the birth of Carl Friedrich Gauss, the mightiest mathematician since the day of Sir Isaac Newton. Indeed, some writers have ranked him as the equal of the latter, but this question had better be left undecided, since Gauss himself would be the first to give place to Newton, to whom he always applied the adjective *summus*. Gauss has been called the "prince of mathematicians" and "Archimedes of the nineteenth century."

It seems that the higher the genius of a man, the later does a definitive biography of him appear, notwithstanding the recent flood of biographies. Several monographs in German have been published, but as yet no definitive biography of Gauss has appeared. A committee of scholars at the University of Göttingen is still engaged in editing the works of this scientist, and in studying notes left at his death. In the rooms he formerly occupied there has been fitted up a Gauss-archive.

Gebhard Dietrich Gauss was born on February 13, 1744, and assisted his father in business at Brunswick, Germany. On April 28, 1768, he married Dorothea Emerenzia Warneken Solerich, and to this union was born one son, Johann George Heinrich, on January 14, 1769. The mother died on September 5, 1775, aged thirty years. Gebhard Dietrich married (on April 25, 1776) Dorothea Bentze, the daughter of Christopher Bentze, a stone mason in Velpke, a small village near Brunswick. Their only child, Carl Friedrich Gauss, was born on April 30, 1777.

The house where this important event occurred has been well preserved. The late George Hieb was largely responsible for the establishment of a room in this house at No. 30 Wilhelmsstrasse (formerly Wendengraben), where one may see all sorts of Gauss relics, such as furniture, letters, books, photographs of his near relatives and many descendants.

Dorothea Gauss reached the ripe old age of ninety-seven and spent the last twenty-two years of her life under the loving care of her son at the Göttingen observatory. Gauss and his father never had any quarrels, but in his home Gebhard Dietrich was often dominating and uncouth. He died on April 14, 1808.

According to Gauss' own story, his mother could not tell him the exact day on which he was born: she only knew that the birthday fell on Wednesday, eight days before Ascension. This circumstance was the occasion of his discovering the formula by which one can reckon the day of the month on which Easter falls, for any year.

He often said that he could count before he could talk. Many stories are told of his precocity. At the age of seven, in 1784, he was sent to school, and for two years instructed by Büttner in reading and writing, with nothing as yet appearing to distinguish him especially from his fellow pupils. However, when he reached the arithmetic class he soon attracted the attention of Büttner.

Johann Christian Martin Bartels was Büttner's assistant, and a young mathematician of no mean ability. He took a great interest in this promising young child, furnished him the necessary books and taught him the theory of infinite



THE BIRTHPLACE OF CARL FRIEDRICH
GAUSS IN BRUNSWICK

series and analysis. In 1788, young Gauss entered the gymnasium; here he showed great ability in the ancient languages. Through Bartels, Privy Councillor von Zimmerman informed the Duke of Brunswick, Carl Wilhelm Ferdinand, in 1791, about the case of Gauss, whose father was opposed to the continuance of his education. The duke resolved to furnish further means for the child's education.

As a protégé of the duke, Gauss entered the Collegium Carolinum in 1792. There he learned the modern languages and continued his study of the ancient languages. Even at his age this youth carried on private mathematical researches during this period.

In 1795, Gauss entered the University of Göttingen, still undecided whether to

devote his life to mathematics or philology. On March 30, 1796, one event, more than any other, enabled him to decide this question, *viz.*, the discovery of a method of inscribing a regular polygon of seventeen sides in a circle, with straightedge and compasses. Gauss always considered this one of his greatest discoveries, possibly due to the fact that it had escaped the eyes of mathematicians for two thousand years. The complete theory of circle-division and primes was elaborated in his immortal work, "*Disquisitiones arithmeticae*" (1801). This treatise is widely conceded to be the greatest piece of human ingenuity since the publication of Newton's "*Principia*." The visitor to the park in Brunswick to-day can see on the Gauss monument there a regular polygon of



THERESA GAUSS
THE YOUNGEST CHILD OF C. F. GAUSS

seventeen sides engraved on the base. This monument is by Schaper.

In a letter to Schumacher, Gauss says that he had used the method of least squares since 1794. One of Gauss' student friends was Johann Joseph Anton Ide, also from Brunswick: he became professor of mathematics at the University of Moscow, and died there in 1806. However, his most intimate friend was Wolfgang Bolyai, a Hungarian who was somewhat older than Gauss. They would take long walks together, discussing metaphysical views on mathematics. A frequent topic of conversation was Euclid's axiom of parallels; many prominent scientists had made attempts to prove this axiom. It later occurred that Bolyai's son Johann published a little volume on non-euclidean geometry. Gauss read this, praised it highly, said that the contents coincided with his own investigations, and declared that he was glad to have been anticipated in this field by the son of his old friend. The correspondence between Bolyai and

Gauss continued up to the death of the latter.

On July 16, 1799, Gauss received his doctoral degree; the thesis topic was: "*Demonstratio nova theorematis omnem functionem algebraicam rationalem integram unius variabilis in factores reales primi vel secundi gradus resolvi posse.*" This was the first rigorous proof of the fundamental theorem of algebra, which he had already discovered in October, 1797. He gave two new proofs in 1815 and 1816; on July 16, 1849, at the celebration of his fiftieth anniversary of attaining the doctorate, Gauss gave the first proof of 1799 in altered form.

On New Year's day, 1801, Piazzi in Palermo discovered a star of the eighth magnitude, which he thought was a new comet. Piazzi's excellent observations showed that this body moved in a circular orbit, rather than a parabolic orbit, as required for a comet, between Mars and Jupiter. The astronomer Olbers, an



MINNA WALDECK GAUSS
SECOND WIFE OF CARL FRIEDRICH GAUSS
(FROM A PASTEL PORTRAIT).

intimate friend of Gauss, rediscovered this planet and informed him about it. He at once set to work to calculate the orbit from the given data, according to Kepler's laws. Suffice it to say, he formulated a method of computing *elliptic* orbits, which placed him in the first rank of astronomers for all time. This asteroid was later named Ceres. In the summer of 1802 he took observations of Pallas. The direct outcome of this work in astronomy was the publication at Hamburg in 1809 of his "*Theoria motus corporum coelestium in sectionibus conicis solem ambientium*." For this epoch-making work he received the Lalande Prize of the French Academy in 1810. In 1802 the Czar of Russia had attempted to secure Gauss as director of the observatory at the Petrograd Academy and later efforts were made to secure him for Berlin and Vienna, but all these overtures failed.

After his return from Göttingen, Gauss was a frequent visitor at the home of George Carl Ritter in Brunswick. Here he became acquainted with Johanna Osthoff in 1803; she was the daughter of Christian Ernst Osthoff, a man of moderate means, proprietor of a local tannery. Johanna was the only child, born on May 8, 1780, the pride of her parents, spirited, kind, happy and gifted with understanding. From the very beginning Gauss felt himself attracted to her, and on July 12, 1804, wrote her the following letter:

My true friend, receive favorably the fact that I pour out my heart, in writing, before you, about an important matter, regarding which I have found no proper opportunity to mention up to the present.

Finally, let me say it from the fullness of my heart, that I have a heart for your silent angelic virtues, an eye for the noble features which make your face a true mirror of these virtues. You, dear modest soul, are so far removed from all vanity that you yourself do not realize your own value; you don't know how richly and kindly heaven has endowed you. But my heart knows your worth—O! more

than it can bear with repose. For a long time it has belonged to you. You won't regret it! Can you give me yours? Dear, can you grasp the proffered hand, do it gladly? My happiness hangs on the answer to this question. Indeed, at present I can't offer you riches or splendor. Still, dear, I can not have erred as to your beautiful soul—you are certainly as indifferent to riches and splendor as I am. But I have more than I need for myself alone, enough for two young people to start a carefree, agreeable life, not thinking at all of my prospects for the future. The best that I can offer you is a true heart full of the warmest love for you.

Ask yourself, beloved friend, whether this heart completely satisfies you, whether you can reply just as sincerely to its feelings, whether you can contentedly make the journey of life hand in hand with me, and decide soon.

I have placed before you, darling, the desires of my heart in artless, but candid words. I could have done it in entirely different words. I could make for you a portrait of your charms, which you, although it would be nothing more than the truth, would have received as flattery; with burning colors I could make for you a picture of my love—to be sure, there I would be allowed only the expression of my feeling—a portrait of the bliss or disconsolation which await me ever after you have accepted or rejected my desires. But I didn't want to do that. At least, don't mistake the pureness of my unselfish love. I don't want to bribe your decision. In the sincerest concern of your life you must not allow any unusual considerations to influence you. You are not to bring a sacrifice to my happiness. Your own happiness alone must guide your decision. Yes, dearest, so warmly do I even love you, that only possession of you can make me happy, if you are of the same feeling.

Dearest, I have exposed to you the inner part of my heart: passionately and in suspense am I waiting for your answer.

With all my heart,

Yours,

C. F. GAUSS.

Brunswick, 12 July, 1804.

Three months passed before the wooer received an answer to this letter. Johanna loved Gauss, but through idle gossip had heard the name of a wealthy young lady connected with that of Gauss. This report having been corrected, the two became engaged on November 22, 1804; three days later the young lover said to a friend, "Life

stands like an everlasting spring with new glittering colors before me." On October 9, 1805, Gauss and Johanna were married and occupied the apartment he had had as a bachelor at Ritter's house.

Their first child, Joseph, was born here on August 21, 1806; there are reasons for believing that he was his father's favorite child. Joseph became a Hanoverian artillery officer, and later visited the United States in the late thirties, then became Oberbaurath and member of the department of Hanoverian railroads and telegraphs, his death occurring on July 4, 1873. He married Sophie Erythropel, daughter of a physician in Stade, born on January 20, 1818, and died on April 6, 1883. One son was born to this union, Carl August Gauss, April 10, 1849, who married Anna Ebmeier, of Stolzenau. Their eldest son, Dr. Carl Joseph Gauss, born on October 29, 1875, is ordentlicher professor and director of the Women's-Clinic at the University of Würzburg, Bavaria. He is noted for work in the field of X-ray, painless childbirth and twilight sleep. Carl August was the only grandchild of the mathematician living in Germany, and died at his home in Hameln on January 22, 1927; his younger son Wilhelm lived at home with him, and his daughter is the wife of Judge Noeller in Gummersbach.

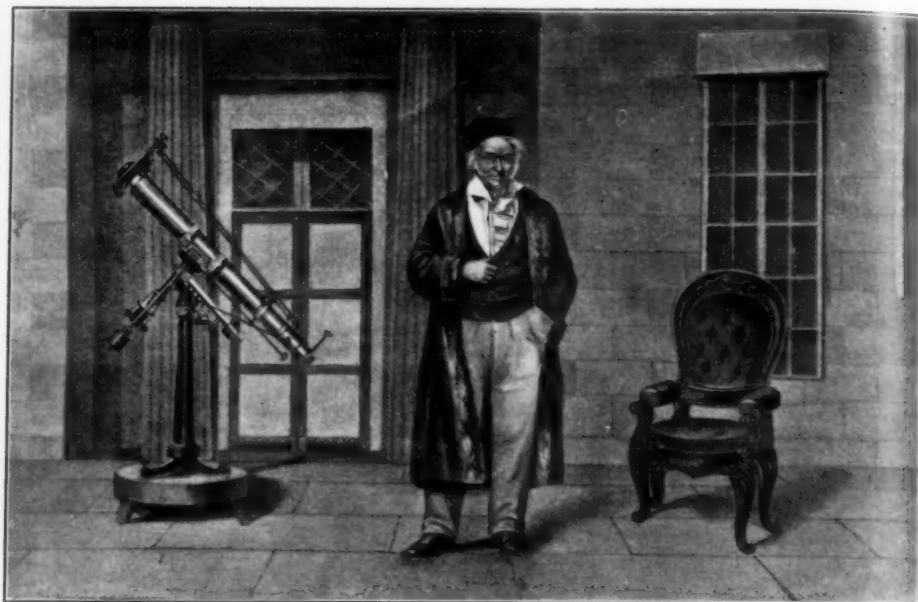
On November 21, 1807, Gauss and his family settled in Göttingen, where he had accepted the professorship which was to continue as his occupation for the remainder of his life. His second child, Minna Gauss, was born there on February 29, 1808. In 1830 she married the celebrated Orientalist and theologian, George August Heinrich von Ewald; they moved to Tübingen, where Ewald had accepted a position as professor of theology in 1837, and she died there on August 12, 1840, leaving no children. Her death was a severe blow to her

father, who loved this daughter deeply; Minna is said to have resembled her father very much in personality. Ewald later returned to Göttingen, married the second time a Miss Schleiermacher, and was survived by her and one daughter, his death occurring on May 4, 1875.

The third child of Gauss was born on September 10, 1809, named Louis, and Frau Johanna died on October 11. The infant died on March 1, 1810, and on April 1, Gauss became engaged to Minna Waldeck, the second and youngest daughter of Councillor Waldeck, a professor in Göttingen University. She had been a close friend of Frau Johanna. There were three children of this marriage:

(1) Eugene, born on July 29, 1811, was educated at the University of Göttingen; he came to America in 1831, enlisted in the army, and was sent to Fort Snelling, Minnesota. At the expiration of his term of enlistment he became connected with the American Fur Company, later settling in St. Charles, Missouri, where he lived for many years. His death occurred on July 4, 1896, at his farm in Boone County, Missouri. He had various business interests, such as lumber, flour milling, etc. On February 14, 1844, he married Henrietta Fawcett (born on February 3, 1817), whose family had moved to Missouri some years before from Rockingham County, Virginia. To this union seven children were born, three of whom are now living. Henrietta Gauss died in November, 1909. Eugene Gauss was a Christian gentleman of high moral character and had intellectual qualities of a type similar to that of his father.

(2) Carl Wilhelm, born on October 23, 1813, in Göttingen; he came to America in 1837, and had married Louisa Aletta Fallenstein, a niece of the astronomer Friedrich Wilhelm Bessel, shortly before sailing from Germany. He stopped at St. Charles for a short time,



GAUSS AT THE OBSERVATORY IN GÖTTINGEN

but moved to Glasgow, Missouri, where he engaged in business, later living on a farm near Brunswick, Missouri, but finally locating in St. Louis, in 1855, where he engaged in the wholesale mercantile business up until his death there in 1879. He was a very affectionate man, generous and possessed of splendid spiritual and intellectual powers. Two of his sons are living at present, one in Colorado and one in Missouri.

(3) Theresa, born on June 19, 1816, and died childless on February 11, 1880; after the death of Frau Minna she assumed charge of the household, and with love and tenderness she faithfully cared for her father until his death. In 1856 she married an artist named Constantine Staufenu, with whom she had corresponded uninterruptedly for fourteen years. They lived in Dresden; Staufenu married again after her death, and his second wife returned in her will the property that had come from the Gauss family.

In 1808 Heinrich Christian Schumacher had come to Göttingen to study mathematics and astronomy; he and Gauss became the warmest of friends and scientific collaborators, their correspondence continuing up to Schumacher's death in December, 1850. In 1810 Gerling, Nicolai, Möbius and Eneke came to Göttingen, which became the mathematical mecca of Europe. Needless to say, the fame of this town has rested on the Gauss tradition. He did not allow students to take notes in class on his lectures, for fear they would lose the thread of his argument. These men became very fond of their great teacher and later distinguished themselves in their chosen fields. The students would be seated around the large table in rather informal style, and Gauss would take great care to explain in detail every step in the reasoning—something which a reader does not always find in his published works. On several occasions he complained of lack of ability or of prep-

aration in his pupils, but these occasions are rare. Perhaps his most celebrated pupil was George Friedrich Bernhard Riemann, 1826-1866, the geometer, whose paper Gauss chose from the three themes submitted in 1854 to be read before the Philosophical Faculty. This monograph, "Ueber die Hypothesen welche der Geometrie zu Grunde liegen," immortalized Riemann's name in the discovery of non-euclidean geometry, and, indirectly, reflected to the credit of Gauss, his teacher, who had been meditating on the subject for some years, as we know from his letters and other evidence, although he never published anything on the subject. Riemann succeeded Dirichlet (who was Gauss's successor) in 1859 as professor of mathematics at Göttingen, which position he held until his death. It is said that Gauss often gave his students skillfully contrived mnemonic schemes to enable them to memorize very involved mathematical formulae. As for himself, we know that his genius had no difficulty in such matters, and that he also delighted in long, mental or written, arithmetical calculations, as did his son Eugene; both exhibited the utmost patience.

About 1810 Gauss interested himself in optics and also dioptries. His results and formulae found practical application after his time. In 1840 he published his "Dioptrische Untersuchungen," and in 1843 he presented before the Royal Society of Göttingen, of which he was director, his "Dioptrische Studien." In 1812 he had published his treatise on hypergeometric series, and among other achievements placed the imaginary on a firm basis.

In 1818 Gauss was commissioned to carry out the triangulation of the kingdom of Hanover, following similar work of his friend Schumacher in Holstein, and later for all Denmark. This work occupied his time rather extensively from 1821 until 1826 and to some extent

as late as 1848. This fact was lamented by some writers who felt that too much of his time was taken by trivial and routine matters which could have been handled by one whose time was not so valuable. He was assisted by Major Müller and his son Joseph Gauss. The science of geodesy reached a new point of development through his labors in this field. There were also several rather concrete results of this undertaking. The old geodetic instruments were unsatisfactory, and one afternoon (1821) while Gauss and his son Eugene were walking along, the father, noticing the light of the setting sun reflected from the window-pane of a distant house, thought of the heliotrope; in the simple form, this instrument consists of a plane mirror 4", 6" or 8" in diameter, which may be rotated about a horizontal or a vertical axis. This mirror is at the station to be observed, the sun's rays reflected by it impinging on the distant observing telescope. The heliotrope is used in geodesy for observing stations that are far removed from each other, is pleasant to operate, and to the observer it appears to be a star of the first or second magnitude.

In July, 1821, Gauss measured with this instrument the classic geodetic triangle, Hohenhagen, Brocken and Inselberg. To-day there is a lofty Gauss-tower on the Hohenhagen to commemorate the work of this scientist. In it there is a splendid marble bust of Gauss by the late Professor Gustav Eberlein, a Gauss-stone or marker which he used in his geodetic observations there, and also the first heliotrope. It is interesting to note that William II, as Kaiser, gave 4,000 marks toward the building of this tower. As final results of the geodetic work, we may consider "Disquisitiones generales circa superficies curvas" (1827) and the two "Abhandlungen über Gegenstände der höheren Geodäsie" (1843, 1846).



CARL FRIEDRICH GAUSS

In the summer of 1831 Gauss had begun to study crystallography, but this subject did not make a great appeal to him, notwithstanding the fact that he made some valuable contributions to the science. At a scientific meeting in Berlin in 1828 he had met the young physicist, Wilhelm Eduard Weber, who, in 1831, accepted the professorship at Göttingen. Both were devoted to their own subjects, and they complemented each other. They collaborated in 1833 in producing the electro-magnetic telegraph, the signals being given by the deflection of a galvanometer needle. The wires extended from the observatory to the steeple of St. John's, and from there to Weber's physics laboratory. The inhabitants of Göttingen saw Wilhelm Gauss helping his father and Weber string up the wires over the house-tops, and upon their learning that it was to carry an electrical current, they became excited, so that Weber had to write to

the magistrate to explain the purpose. The line was destroyed by lightning in 1845. It is beyond the projected scope of this article to describe in detail the telegraph which they used, but is sufficient to say that they devised an alphabet, and could send messages accurately, with a speed of about seven or eight words a minute, by using an induced current. Germany has always been proud of these two men for such an early achievement. Gauss lived to see some of the development of telegraphy, and always took great pleasure in noting it. His system was readily applied by Lord Kelvin to ocean telegraphy. The last letter of Gauss, written to Sir David Brewster, was about the early telegraph.

It is significant to note that both Gauss and Morse attached military importance to the telegraph. The former, in a letter to Schumacher, mentions the fact that the Russian czar might transmit his orders immediately from Petrograd to Odessa; Morse wrote a letter to the new republic of Texas, offering the government his recent invention of the telegraph, pointing out the military advan-



GAUSS AND WEBER

tages of such a contrivance. It was, of course, not accepted.

Gauss and Weber investigated the science of magnetism very thoroughly, and laid the foundation for the modern study of it. They formulated fundamental laws and theories in this field. Two magnetic units are named in their honor. Through their efforts and the efforts of Humboldt were established observatories for terrestrial magnetism. Gauss invented the bifilar magnetometer which is used to measure changes of horizontal force; in the mechanical constructions he was ably assisted by Johann von Lamont, a Scotch Jesuit, then living in Germany. Regular magnetic observations were started in 1834; already in 1833 Gauss had published his "*Intensitas vis magneticae terrestris ad mensuram absolutam revocata*." Together with Weber he published in 1840 an "*Atlas des Erdmagnetismus*"; then came the important "*Resultate aus den Beobachtungen des magnetischen Vereins*" (1837-1843).

On April 18, 1839, Frau Dorothea Gauss, the mother of Carl Friedrich, died; she had always been very proud of her only son, and he showed the greatest affection for her. She had become blind several years before death, but this did not stop her usual activity. Gauss was an excellent father to his family; he loved social intercourse and conversation; in his home he was always glad whenever the simple meal was accompanied by some discussion or poetic subject. In the family nothing was too unimportant; for instance, he kept in a note-book the dates when his children cut their teeth, and he kept a register of all the keys to the rooms of his observatory and his home. He was very fond of music, especially singing. Whenever he heard a beautiful song he would go and write it down. Frequently he played whist. He had a subtle, keen sense of humor which might manifest itself in friendly satire. In his later days Gauss

would go daily to the so-called literary museum to consult the many newspapers there, where he was known as a *Tiger for News*. What interested him especially was political and financial news. He was always solicitous about the welfare of his country, particularly during the Revolution of 1848, probably because he thought back to his experiences during the Napoleonic wars; he used to say, "*Mundus vult decipi*." Gauss knew how to invest his money well, unlike many men of science, leaving a large estate at his death. It is said that the czar of Russia once offered him a post as minister of finance, and also that he once refused an offer of a title of nobility. He never wore any of the many decorations which the different governments had showered on him. His daughter Theresa, in a letter on the celebration of his fifty years' doctorial jubilee, bewails the fact that none of his beloved sons could be with him on his day of triumph.

Gauss did not like to travel, and from 1828 (his trip to Berlin) until his death, only once did he spend a night away from the observatory, it being in 1854 when he attended the opening of a railroad and saw a locomotive for the first time.

About 1840 he studied Sanskrit, but only for a short while. He was acquainted with the modern European languages and could speak many of them. In his sixty-second year he took up the study of Russian, and in two years he had mastered it completely, being able to speak it and to do his correspondence to Russia in the native tongue. He had probably been urged to do this by a desire to read Lobachevsky's work on non-euclidean geometry in the original. He read English often, in his last days completing Gibbon's "*Decline and Fall of the Roman Empire*," and the works of Sir Walter Scott, which he greatly admired.

Gauss considered all philosophical



GAUSS-WEBER MONUMENT IN GÖTTINGEN

ideas as subjective; he was possessed of great religious tolerance, which must not be confused with indifference. He also held that one is not justified in disturbing another's religious belief, in which they find consolation for earthly sorrows in time of trouble. The striving after truth and righteousness were the foundations of Gauss's religion. He believed firmly in the immortality of the spiritual individuality, in a personal permanence after death, in a last order of things, in an eternal, righteous, omniscient and omnipotent God. In his own life he exemplified these teachings, being a man of great generosity, kindness and meekness of spirit. His neighbors applied to him the phrase: "Modest and simple, but worthy and strong."

Gauss had excellent health, a strong constitution, had never been seriously ill, but in the last two years of his life he suffered from insomnia and several other ailments of old age. At last dropsy and heart failure developed, and he died on February 23, 1855, surrounded by relatives and friends. On the morning of the 26th, amid a large gathering of students, friends, townspeople, relatives and officials, his funeral was held; Sartorius Wolfgang von Waltershausen, his close friend, and Ewald, his son-in-law, delivered the funeral sermons, and after several hymns, including one of Luther's, and the chaplain's benediction, he was laid to rest in the old churchyard near the Albanitor in Göttingen. The one word GAUSS is engraved on his tombstone, which is unpretentious and plain—in keeping with the character of the noble man. It is a fact interesting to psychologists that R. Wagner studied the brain of Gauss, and found its weight to be 1,492 grams, and the cerebral area equal to 219,588 square centimeters, in whose highly developed convolutions perhaps lies the explanation of his genius.

After his death this powerful mathe-

matician was widely honored. There may be mentioned the Schaper monument in the park on the Gaussberge in Brunswick, his birthplace, and the Gauss Bridge in that city. Many streets have been named for him. In Göttingen, there is the Gauss-Weber monument, by Professor Hartzler, in honor of their invention of the telegraph. On the Potsdam bridge in Berlin, beside Siemens, Helmholtz and Röntgen, stands a masterful monument of Gauss by Professor Janesch, who has also made for the Royal Agricultural Ministry in Berlin a marble bust of Gauss. Another bust is in the Main-Hall (library) of the University of Göttingen. The ship which made the South Polar expedition in 1901-1903, under Professor von Drigalski, received the name Gauss. His centenary was widely celebrated in Germany, many memorial addresses having been published on April 30, 1877. At the present time, a *Festschrift* is to be published in Brunswick on the occasion of the sesquicentennial of his birth.

After the death of his mother, Gauss had not been in frequent correspondence with his brother George Heinrich, who early in life had been afflicted with severe eye trouble. He had become a member of the artillery, which was then composed of the children of the upper class, more than other branches of the army, and so received better treatment. Outside the service, which allowed much freedom—he had to assist his father in his work. Under these circumstances there could not be much hope of promotion, and so after the catastrophe of 1806, he went back home to continue his father's gardening and casket-making. George Heinrich died in his eighty-sixth year, on August 7, 1854, and Carl Friedrich wrote the following rather touching letter to his nephew Gebhard:

I received the sad tidings of your letter of the eighth with heartfelt sympathy. It was grievous for me that for several years I had

remained without any news of my brother. As long as Professor Goldschmidt lived, I was always in touch with Brunswick, because he was accustomed to journey there twice a year to his father who was then still living, and then always made inquiry about the conditions of my brother, and communicated it to me. But Professor Goldschmidt has been dead now for several years, just as all the friends of my youth there. It is the lot of humanity, when one gets old. I am already in my seventy-eighth year, but I will not equal my brother, because I have been feeling the diminishing of my strength for a year. I am unusually glad that I must infer from your letter that the last years of my brother's life were alleviated, as much as the course of events allowed, by the loyal care of your mother, to whom I ask you to convey my heartfelt condolences and greetings.

For thirty-three years I have not seen my native city, and even then for just one day. Now the journey is considerably shortened by the train, because one can come there from here via Hildesheim or Hanover in six or seven hours now, and I suppose in one or two years, when the side-line is opened, in half the time. Whether I will survive until that moment, or whether my strength will permit me to make use of the train, in order to see my native city just once again, is questionable. But it always remains my sincere wish that everything may be well with you and yours.

Within six months Gauss himself was no longer among the living. The following letter of his physician, Dr. Baum, who attended him with unremitting care, written to Humboldt, is interesting in that it gives us a glimpse of the last days of the celebrated mathematician:

GÖTTINGEN, MAY 28, 1855.

Your Excellency:

If I had been obliged to prepare you for the sad news before the death of our great mathematician, the news, which is now the more unexpected, struck the more painfully for that reason: but I was at that time so completely claimed by the medical care of the venerable man, who in his last months saw only his daughter and me around him, besides the many duties of my vocation, that I therefore ask for indulgence.

As we were talking in the presence of Professor Dirichlet, whom we now call our own with happy pride, a great deal about the last conversations of Mr. Gauss, he urged me to communicate to Your Excellency that Gauss at the last often thought of you, and with much

love. Your last letter made him especially happy and he read it repeatedly and let me read it aloud. When he was once taken unawares by the apprehension that a more advanced old age might bring to him aggravated complaints, he said: "then the thought of my Humboldt consoles me"—an epithet which I have heard him apply to no other name. With joy he believed he recognized your hand in the translation of Arago's Works, where the number of those men is mentioned to whom a final judgment belongs regarding exact experiments: the number in the original is given at about ten, in the translation at about eight: he thought that this diminution, which suited him exactly, could have proceeded only from Your Excellency.

The last days of his life were often very painful owing to the aggravated complaint of dropsy, which the hypertrophy of his heart produced—but still he always maintained his freedom and greatness of spirit, the strongest conviction of his personal permanence, the firmest hope in the still deeper intelligent insight into the number-relationships, which God places in matter and which he would perhaps be able to recognize in the intensive magnitudes, for he used to say 'ο θεος' αριθμετιζει. (God arithmetizes.)

Thus he remained consistent up to the end, so that even in the last weeks he read through the Book *critis sicut deus*, not without vexation, "for the people would be speaking about things, all means of judging which they lacked," but he put an end to it nevertheless, although he thought it once made a sleepless night for him.

Only in the last eighteen hours did consciousness leave him, only now and then did it come back for a short time for an utterance of love or for a desire—then silently he slept away.

May these few words be not disagreeable to Your Excellency, these words, which I wrote in the most respectful and grateful love, in which I remain even to the end

Your Excellency's most truly devoted

BAUM.

The following words inscribed under the portrait of Gauss in the Munich Museum best summarize the work of this scientist:

Sein Geist drang in die tiefsten Geheimnisse der Zahl, des Raumes, und der Natur;

Er mass den Lauf der Gestirne, die Gestalt und die Kräfte der Erde;

Die Entwicklung der mathematischen Wissenschaft eines kommenden Jahrhunderts trug er in sich.

CRIME AND PUNISHMENT¹

CAUSES AND MECHANISMS OF PREVALENT CRIMES

By the Honorable WILLIAM McADOO

CHIEF CITY MAGISTRATE, NEW YORK, N. Y.

WE are confronted in this country for some time past and at present by an army of outlaws, young fellows, mostly between the ages of sixteen and twenty-six. They are the gunmen and those who commit crimes of violence, aided by pistols, which are as common in the United States as lead pencils, and the speedy motor cars as the mechanisms of prevalent crimes. The large majority of these fellows are lacking in the normal emotions of love, sympathy, kindness, gratitude, friendship and a sense of civic obligation, but on the contrary they are cruel, cowardly, heartless, selfish, ungrateful and I may add godless and dangerous, and above all they are determined that they will never do any honest, continuous work. Living in the richest country in the world, in which the sum of a million dollars is talked about as ten thousand dollars would have been some years ago, their idea is to get what they call "easy money" by criminal methods so that they may not have to work and have it to spend on their appetites, lusts, passions and vanities, for they are immensely vain and proud of their criminal records. The money they get by stealing and robbing goes mostly to gamblers and women of their own type, and the balance is spent recklessly in a style of living to which they ordinarily would not be accustomed.

Just now the country is being flooded by opinions from all classes of men and

women as to the reasons for the existence of this desperate, cruel and cowardly army. They are attempting to answer the question, what caused these young fellows to adopt deliberately a criminal career instead of becoming useful, industrious and law-abiding citizens. Some of the writers and speakers in the press, the forum and the pulpit seem to believe that it is from poor economic conditions. They say that when these young men do work they are underpaid or they can not find proper employment or that the cost of living is so high that the salaries they would receive for work would not be sufficient to meet their wants; that there is not sufficient employment for all of them; that they have been educated beyond manual labor and they can not find employment as clerks and the like, and also that they are not permitted to learn trades because of the limitations placed upon the number of apprentices by the trade unions.

For many years past, both as police commissioner and for sixteen years as chief city magistrate superintending the work of thirty-seven courts and fifty-seven other magistrates, and through which courts there pass in the year nearly five hundred thousand people as defendants, from spitting on the sidewalk to murder, and having had unusual opportunities for noting conditions, economic, social, political and religious, it is my firm belief that the main trouble with these fellows is that they will never do, as I have said before, any honest, continuous labor. The great majority of them have started out de-

¹ Addresses presented before Section K—Social and Economic Sciences, American Association for the Advancement of Science, Philadelphia, December, 1926.

liberately with their minds made up that they will get easy money by criminal methods, and the pistol makes intimidation and robbery easy and the motor car is at hand for a successful escape after the crime has been perpetrated. It is preferable for them to steal a car and use it on a criminal enterprise rather than one which may have come into their possession legitimately. Unfortunately, in most of our big cities there is a small number of taxicab drivers, who bring disgrace upon the rest of that body by lending themselves and their car for criminal purposes so that they may share in the proceeds of successful robbery. This has brought about a humiliating and astonishing scene here in New York and other big American cities, in that the money taken from and to banks and to industrial concerns is carried about in heavily armored cars and protected by men armed with pistols. A mere suggestion of such a change in the method of delivering money some years ago would have been laughed at as an impracticable and unnecessary means of transferring large sums of money. Our banks have to be guarded by armed men as in time of serious, civil disturbance.

Recently, as a sample of the times in which we live, a man, himself a gambler and a bootlegger, went into a place where they were playing a game of craps or dice-throwing for very large sums of money. He won \$50,000, which was offered to him in cash. With a significant look around the room at the crowd present he handed it back to the dealer and said, "I am not foolish enough to undertake to walk out of this place with that amount of money. I will take a check."

Other writers and speakers are insisting that these young fellows are the victims of heredity and environment, products of congested tenement houses, pedigree-marked by elements of physical, moral and spiritual decadence, drunken, coarse-living, vicious and immoral par-

ents. Others insist that these soldiers of crime are to be sympathized with and kindly treated and reformed.

In this country no young fellow who wants to work need go idle, and the wages are the highest in the world in all classes of employment, so there is no economic distress which would force recruits into this murderous army. It may, therefore, I think, be safely concluded that my assertion that they will not work is absolutely grounded in fact. They are lazy loafers and will continue to be so once they are started on a criminal career. They will rob, steal, swindle, terrify, sponge on their parents, rob their own family, sell narcotic drugs, tout for racetrack bookmakers, and in some instances and in certain localities terrorize and blackmail the whole neighborhood through fear of them. I am sorry to say that I do not think that the large majority of them are reformable under any conditions. Can psychiatry and psychology actually tell us how far heredity and environment are responsible for them? Can we analyze the character of a Gerald Chapman, Whittemore and "Bum" Rodgers by ascertaining their mental ability or lack of it? Science can only tell me as to the fellow's head. It will leave me groping in the dark as to his character. I want to know about his outlook on life and his personality. How, otherwise, is it that of large families, say five or six young men, only one will turn out to be a "black-sheep"? How is it that the other five born in a congested tenement house in an undesirable locality, of the same parents, do not go wrong and are in all respects good citizens. Of course, I understand that we all have different finger-prints and it is a matter of common observation that members of families are different, radically so in temperament, spirituality, morality, industry and very much so in physical appearance.

I am not underrating these new sciences. On the contrary, I believe that they should be used freely in our courts and custodial institutions, and I would like to see them able to give us an analytical biography of the subject by which we could look into the heart of the man as well as his head. Some of the most notorious crooks and criminals have been extraordinarily smart fellows and I have no doubt would pass good mental examinations, but it is a peculiar bent of character and personality that we should inquire into. Possibly the aftermath of the great war and the immense wealth of this country has something to do with the psychological atmosphere, which we might so term it, in which these fellows exist and which brought them forth. I regret to say that it is my opinion, from experience, that of the large majority of pickpockets, for instance, who pass through the magistrates' courts, most of them will continue picking pockets as long as they are alive. When we give one of them six months in the workhouse, it is with the satisfaction that during those months he will not be able to pick the handbags of hardworking women or the pockets of comparatively poor men in public conveyances. When they get out they will go on picking pockets again. Giving that type of pickpocket and gunman six months or six years is simply beneficial to the community in keeping him from criminal activities during the period for which he has been sentenced. It will not reform him, whether he gets six years, twenty years or life, nor can we make salvage of any very considerable percentage of this type of criminal. If we save from 5 to 10 per cent. we are doing extraordinarily well.

My own idea for many years past is that in this state we will eventually have to create a great custodial institution, which will neither be a state's prison, penitentiary, a jail or a reformatory, but will be a self-supporting community with

farms, shops, churches, schools and every other feature of modern progress. To this custodial institution will be committed the type of fellows that I am talking about. They will be given an indeterminate sentence with a substantial minimum, during which period they will be under constant observation of experts, experienced men and women, physicians, psychologists, psychiatrists, and live their lives in a mental, moral and spiritual atmosphere in the hopes that they can be reclaimed. They will not be discharged until they are pronounced, as it were, cured, and the community will have the assurance of those in charge of them that they are no longer dangerous and a menace, that this young fellow, who has been a gunman, and the other young fellow, who has been a pickpocket, have really been regenerated, remade, reclaimed and can be safely turned back to the community without danger to it.

How many of them will be turned back? I do not know. As I said before, there might be hopes of saving a percentage of them. As it is now they go in and out of jails, workhouses, penitentiaries and state's prisons until they get long, criminal police records and the very fewest number of them are ever shown to have been reformed by the deterrent effect of the present treatment.

We will get nowhere with a sloppy sentimentalism on the one hand or a ruthless inhumanity on the other.

My own idea of a prison is that its chief use at present is that it keeps the dangerous element of crooks, criminals, gunmen, swindlers and pickpockets from practicing their arts for the time they are in prison, and I do not believe that they would be reformed or deterred in any way on their release by the fact that they were subject to the old, harsh, cruel methods that used to prevail in the old-fashioned prisons.

The pistol is the curse of America, and they are almost as plentiful as lead pencils in this country, good citizens and

bad citizens possessing them. This is the greatest market for the sale of pistols in the world. In addition to our own manufacturers, those imported from Europe include the output from factories in Spain, whose total output of these murderous weapons finds its way to this market.

There are more people shot to death or wounded by pistols in the United States in one year than in all the rest of the world besides. The pistol is not a sporting weapon. It is intended to kill or maim human beings, or by intimidation to rob them when in the hands of bandits and outlaws.

There are more armed young fellows in the United States between the ages of sixteen and twenty-six whose aim is to get easy money through the pistol and the motor car than in all the rest of the world.

Numerous fortunes are made by the mail order agencies and houses selling pistols. One man here confessed to the police that he had made \$400,000 in two years sending pistols through the mails. Pistols can be bought as cheaply as \$5.00 apiece or less. Down in Texas and some other states, the Negroes rent the pistols and pay for them on the installment plan. They call it "renting a gun" and most of them who go to the penitentiary reach there by the pistol route.

Recently, there were 500,000 people on strike in England, and not one shot was fired during the whole period of the strike which continued for months. Of the twenty-two thousand policemen in London not one carries a pistol and the criminal classes are not armed; hence they only had fifteen murders in 1924 as against a terrible list in all our cities and even small towns and villages.

We have no accurate statistical information in the United States as to the total number of crimes as given in our police department reports for various cities, large and small. The London police report, under the heading "number

of crimes known to the police," gives the total number of reported and ascertained crimes and in the next column the total number of arrests, that is, they may charge themselves with housebreaking and stealing—1,940 such crimes and only 158 arrests; attempts at murder—23, arrests 11; robbery and assault with intent to rob—42, arrests 36, etc., etc. If this rule were followed by the police of all our large American cities we would know more than we do now as to the total number of crimes. As murders, however, can not be concealed we may rightfully assume that the official reports give the total number, but that does not cover murderous assaults and other crimes.

The pistol manufacturers, dealers, importers and mail order people are represented in all our capitals, both state and national, by one of the most efficient, best organized and cleverly managed lobbies connected with any other business enterprise. They flood the country with specious and easily answered arguments in favor of pistols. Among other things, they are constantly reiterating that under such laws as the Sullivan Act in New York state and other states only crooks, murderers, robbers and dangerous criminals can get guns, which of course is not true, because any decent, orderly citizen, if he shows good cause, can get a permit here in New York to carry a pistol or have one in his house, and all our banks are thoroughly armed with pistol-bearing employees. If this statement of the pistol people were true, then how do they account for the immense number of pistols that flood this country from end to end? Ascertain the number of pistols manufactured in this country; estimate the number imported every year, and we are asked to believe that only crooks and dangerous gunmen get these guns. Well, if that is true, then there must be from 50 to 75 per cent. of the whole population of the United States that are outlaws, criminals and dangerous gunmen carrying guns.

because the argument leads us to suppose that honest, law-abiding people are disarmed.

All the literature and advertising for pistols seems to be based upon an assumption which is purely illusory and invented in fact. I assert and I have done so for years past and will continue to do so so long as the facts bear it out, and that is this, that the pistol as a defensive weapon is utterly and positively useless in the hands of a law-abiding, orderly citizen because of the element of surprise on the part of the robber, burglar or assassin. I have been held up, and if I had a dozen pistols they would have been useless. Time and time again bank messengers, loaded with pistols, have been shot down by robbers who had carefully planned the attack, surprised them when they least expected it and robbed them. Hundreds of homes have been robbed and burglarized where the owners had pistols. If I am going to hold you up, rob you, burglarize your house or assassinate you, I will have planned it all out carefully beforehand; the whole operation would be strategically considered; you have gone days, months and years without such an attack and you will not be expecting it at the moment when it is thrust upon you. The robbery, the assault and the murder are the unlooked-for things. Carrying pistols or dozens of them is no defense against such happenings.

No one has a constitutional right to carry a concealed weapon like a pistol. Any citizen can go all over this country, including New York state, with a rifle on one shoulder and a shotgun on the other and there is no law to interfere with them.

I could give tables of various American cities, such as New York, Boston, Chicago, San Francisco, New Orleans, in fact all of our cities as against the great cities in Europe, and the comparison is a national disgrace and humiliating as to the shooting and killing records.

I would as soon place a full-venomed, cobra snake in my house as a loaded revolver. Look at the tragedies in the morning newspapers, where husband shoots wife, man shoots mistress, one child shot the other, frenzied head of the family kills the whole family and himself, until all over the country it is bang! bang! bang! every hour of the day and night.

It will take some time to educate public opinion, but when it has received knowledge of the actual facts, it is my belief that the pistol will have to go, and I hope to see the time when a person possessing, owning or carrying a pistol will lose his or her character as a law-abiding and respectable citizen. When we have convinced people to throw away these murderous weapons, we will then only have to deal with the armed, dangerous professional criminal type, and if we make the purchase and procurement difficult or impossible, and the police authorities do their duty, the battle for law, order and personal and communal security will have been won.

There is an excellent bill now pending in the New York legislature which will reach the pistol at its source, in the factory and in the custom house, and when I say the factory that also will of course include those who make the cartridges. Unfortunately, under the federal constitution a law taxing cartridges, say at one or two dollars apiece and only allowing them to be sold to peace officers in the Army and Navy, might be considered unconstitutional as an attempt on the part of the government to secure police powers by way of taxation. A bill taxing pistols and ammunition for the same was introduced a year or two ago by Senator Copeland, of New York. The bill was drawn by myself and Professor Chamberlain, of Columbia University, but under recent decisions of the United States Supreme Court the bill seems to be open to constitutional objection. I say this because whenever any good bill

appears in any state legislature, the opposition very cleverly get up and say that it should be postponed and we should look only for relief to Washington. As a matter of fact an excellent bill called the Miller Bill, taking the pistols out of the mails, passed by the House of Representatives at the last session, has been favorably reported by the Committee of Finance in the Senate and is now up for action, but every time it comes up somebody opposes it, possibly in the hope it will go over until the 4th of March, thus necessitating its repassage through both houses before it can become a law. Some of the arguments used against this bill a few days ago in the United States Senate were to the effect that the Sullivan Law was ineffective here in New York. In reply to that I wrote to one of the Washington newspapers as follows:

The Sullivan Law, in spite of the handicaps pointed out in your editorial, is so very effective here that if it were repealed the crime wave would be immensely increased and the police arm of government tremendously handicapped and conditions generally would be inexpressibly bad. As it is now, and I am quite sure Commissioner McLaughlin will agree with me, the Sullivan Act is the most powerful weapon that the police have in dealing with dangerous criminals, of which we in common with all other American cities have too many.

As you say in your editorial we have been handicapped by the fact that New Jersey has not as stringent a law as that known as the Sullivan Act, although that state is fully alive to the situation and at the last session of their legislature amendments were made to the exist-

ing law in tending to break up what had been an open market for pistols on the west bank of the Hudson River; but most of all we suffer from flooding this city with pistols by mail, and from here unconscionable rascals send pistols all over the country through the mails.

Since writing the above I saw a statement in the morning newspaper to the effect that the Boston commission investigating these crimes attributes the criminal actions of these young men to the use of "bootleg" liquor. I do not of course know what is happening in Boston, but so far as New York is concerned the gunmen, the loft burglars and the pickpockets do not drink alcoholic liquors, certainly not to excess and they never have. If they were tipplers and drunkards as outlined in Boston, their capture would be easy and they would not be able to carry out the well planned crimes that now take place. I repeat again the clever criminals are not now and never have been drunkards. I believe, however, from the facts and data at hand that a good many of them are drug addicts and under the influence of the drug their senses are even more acute than when they are without it, in fact I have had before me addicts who work in the most perilous sort of employment, as constructors on huge steel edifices going up to forty stories and horse jockeys and others who engage in extraordinarily hazardous employment and who are constantly under the influence of narcotic drugs while so employed.

CRIME IN THE COMMERCIAL FIELD

By Professor JOSEPH MAYER

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IN these days we hear much from the public press regarding a crime wave and the establishment of crime commissions to look into the matter. "The responsibility," as George D. Nathan very well expresses it in the *American Mercury* for February, 1926, "has been placed

upon everything from the late war to the modern novel; from Bolshevism to bad booze; and from insufficient police protection to the automobile and the easy means of escape provided by the latter." There can be no question that there is considerable crime in the coun-

try. But the causal factors are quite different from those ordinarily assessed and a long range view of the situation from the Civil War period to the present day demonstrates that, comparatively speaking, there is no more crime now than there always has been here. That is to say, taking population increase into consideration and taking into consideration also the fact that there is a flaring up of criminal activity at one time and more of a subsidence at another, the proportion of criminals to population has not shown any marked change. The fact is that in the United States—a new country, a frontier country and a country in which police espionage and systematic registration of citizens would not be tolerated—there has always been more crime than in older nations in which everybody is under surveillance from the time he is born to the hour of his death.

In the commercial field, however, there has recently been in America an enormous increase in crime. Here again the actual causal factors are other than those usually given. In the opinion of William B. Joyce, chairman of the National Surety Company—a man who has made a long study of embezzlement, forgery, stock swindling and insurance and credit frauds—the principal cause of the increase in commercial crime in this country is the enormous increase in the volume of American business. Mr. Joyce simply expresses the conviction of most authorities. Here as elsewhere in the field of crime, it is not so much a question of criminal types as it is a question of temptation and opportunity.

Let us for a moment consider how vast has been the industrial development of America in recent years. In the last decade the wealth of the United States has almost doubled. It is now placed at \$300,000,000,000. Several details of this development may be given as illustrative. Out of comparative insignifi-

cance fifty years ago the American money market has risen to first place in international affairs. Our railroads bring in a daily revenue of approximately twenty million dollars. Our telegraph lines carry seven million messages every twenty-four hours. In the same period there are seventy-two million telephone calls, \$1,500,000,000 in bank clearings and six million dollars of imports at a single American port of entry. All these and other increases in the business activities of the nation have made possible the operations of commercial crime on a scale hitherto unheard of in the history of the world. Methods of protection against dishonesty in business have simply not kept pace with our industrial expansion.

That the economic and financial loss involved in criminal activities in the commercial field is considerable will readily be conceded. The exact extent of the annual loss can not, of course, be accurately computed. However, authorities are fairly well agreed that a figure somewhere between two thousand and ten thousand millions represents it. If we take the higher figure of this estimate, our commercial crime cost is three times as much as is now appropriated each year for the running expenses of our government and represents 15 per cent. of the total annual national income. It is just about equal to the sum total of the war debts owed to the United States as a result of the late war. William J. Burns, former head of the Bureau of Investigation of the Department of Justice, and Mr. James E. Baum, manager of the protective department of the American Bankers Association, are practically agreed on setting the present yearly loss due to commercial crime at something like four thousand millions. The following table prepared by Mr. Baum indicates the major categories of crime in the business field and the annual losses involved.

Recent Annual Loss due to Commercial Crime.
(Figures for 1924)

Stock frauds	\$1,700,000,000
Tax and insurance frauds	1,000,000,000
Credit frauds	400,000,000
Burglary, larceny, petty thefts	250,000,000
Embezzlement	120,000,000
Seaport robberies and railroad thefts	125,000,000
Forgery	100,000,000
Arson	50,000,000
Miscellaneous	75,000,000
Total	\$3,820,000,000

We have not the time here to develop at length the ramifications of each of the items on this list. Only a few can be touched upon. With respect to the first item, namely, stock frauds, in which the enormous sum of \$1,700,000,000 is involved each year, there are many interesting details of operation and law enforcement. Millions upon millions of dollars are squandered annually on worthless promotion schemes developed with deliberate intent to deceive and defraud. Oil promotion ventures have lent themselves especially to fraudulent practices. During the years 1918 and 1919 the United States Treasury Department estimated that approximately four hundred million dollars worth of Liberty Bonds were turned over by their holders in return for various forms of fraudulent securities.

Every successful new invention, such as the automobile or the radio, is immediately seized upon by a swarm of crooked professional promoters, who take advantage of newly aroused public interest to unload worthless stock. This form of fraud invades every phase of business life and thrives on the credulity of the average person. The outward forms adopted by swindlers to camouflage their operations are continually changing. One year the public is induced to sink its savings in new oil wells or in foreign exchange trading; another year in land speculation, as in Florida real estate, or in wildcat mining ventures, or in security and commodity

bucket shop operations will be the forms in vogue. Stock frauds grow stronger each year, nor is there any phase of commercial crime which is more difficult to handle through established law enforcement agencies. Security swindlers devise clever methods for covering up their operations and the victims are often reluctant to make known the fact that they have been fleeced.

Credit frauds represent an interesting and complicated category. Under it are included the making of false financial statements, concealment of assets or wrong disposition of assets and the destruction of books of account. Ordinarily three steps in the development of such frauds can be traced: (a) Misrepresentation, (b) diversion of assets, (c) bankruptcy. Misrepresentation as here used takes many forms. For example: Concealment of one or more of the asset items; under-statement or omission of some of the liability items; fraudulent use of the name and credit of another individual or firm; development of a legitimate line of credit for the purpose of later obtaining additional credit for fraudulent purposes.

Arson or incendiarism deserves special mention because it is a most serious menace to society, threatening not only property but life itself. It has been estimated that nearly 50 per cent. of the loss by fire is due to arson—burning property to defraud. During 1924, the fire loss given by T. Alfred Fleming, of the National Board of Fire Underwriters of New York, was approximately \$549,000,000, of which \$220,000,000 was due to incendiarism.

The crime of arson is largely localized in a few cities and in a few sections of such cities because of the exceptional opportunities offered by the presence of a certain type of broker and public advertiser not found elsewhere. It is one of the most difficult crimes to detect, in that the evidence is usually destroyed by the fire. Arson has become a profession. It

is closely allied to fraudulent bankruptcies and other forms of commercial crime. During the deflation period following the war it has shown a marked increase.

Probably the worst arson situation exists in those lines of industry that are affected by fashion—clothing, shoes and hats—particularly women's wear. The profit in these industries is great, provided the goods can be sold while in style. But if a change in fashion or a miscalculation leaves the goods on a manufacturer's shelves, the loss is equally great, for honest disposition can only be made at a price which does not pay for cost of materials and labor. A fire readily wipes out the old stock, the insurance company settles the claim, and the arson criminal can start in business anew. The fire hazard in the New York clothing industry is so great that some fire insurance companies refuse insurance there. This obviously is an injustice to the honest business man, but under the circumstances it is the only course the fire underwriters can pursue.

The miscellaneous group of the foregoing table contains some important subdivisions such as: counterfeiting of trade names used to identify products; using or furnishing to others without the owner's consent the names of customers or subscribers; obtaining money or property by means of bad checks; giving, offering or promising to an agent or employe gratuities, without the knowledge and consent of his principal, with intent to influence his action in relation to his employer's business; and conspiracy by two or more persons to defraud another of property or prevent another from exercising a lawful trade.

Commercial crime, whether it involves two, four or ten billions annually in the United States, is a staggering problem—one that should compel the serious attention of every fair-minded citizen. Nor have efforts to solve it been lacking. The federal government, the

states and private organizations have been busy for some time attempting to curb the evil, and their efforts have not been without some success. In 1922 the attorney-general of the United States announced that 480 cases of commercial fraud were pending in the federal courts at the time and that illegal transactions involving a daily average of \$2,000,000 were being brought to the bar of justice. The Post Office Department, at the beginning of the Coolidge administration, finding that approximately 80 per cent. of fraudulent securities were being disposed of through the mails, began a nation-wide campaign to stop the practice. The effect has been noteworthy and has succeeded in curtailing the operations of some notorious rings of criminals, as in the recent indictment in Texas of ninety-two individuals who during five years had cheated two million investors out of \$140,000,000. Additional appropriations are needed to follow up this excellent beginning. No more profitable way could be found for utilizing the taxpayers' money.

The states have also been busy endeavoring to cope with the problem, some forty of them now possessing blue-sky legislation, the purpose of which is, as the name implies, to prevent the sale of patches of the firmament. By providing commissions of investigation and supervision, information regarding legitimate ventures and actually regulating the issue of securities (as in Illinois), further curtailment of fraudulent operations has resulted.

But there is still little uniformity in these laws; at best they attack only one form of commercial crime; swindlers quickly ascertain in which states there are no such laws or wholly inadequate ones and concentrate their efforts there; and legitimate business has often been interfered with by ill-considered provisions. In short, only a beginning has been made on the part of the states in grappling with this elusive problem.

Private agencies have also been active. The Associated Advertising Clubs of the World have been giving widespread publicity to certain types of fraudulent business practices. The Investment Bankers Association, the Better Business Bureau of New York and the New York Stock Exchange, especially the latter, have instituted vigorous campaigns against financial swindles and bucket shops. The Stock Exchange has of late years followed a consistent policy in refusing the use of its facilities for questionable ventures and in encouraging a high business morality among its members.

Federal, state and private agencies are in one way or another endeavoring to reduce the activities of the commercial criminal, and yet his activities continue with little apparent abatement. What are the reasons for the inadequacy of attempted checks? Why are these efforts not more effective? The answer falls into four categories, the first, already mentioned, centering in the fact that the expansion of business enterprise has been so rapid in recent years in America that it has simply been impossible as yet for instrumentalities of crime prevention to be perfected to keep pace. The other three comprehend the lack of cooperation between preventive and corrective agencies, the crying need of better law enforcement facilities all along the line and an appalling lack of interest on the part of the average citizen.

From the standpoint of better cooperation among corrective agencies, it would seem that the time has come for the federal government to take drastic action, not merely in the Post Office Department or in the Department of Justice, but through some agency with sufficient funds and experts to give the major part of its attention to commercial crime. The Federal Trade Commission was organized to correct certain questionable business practices. Opposition to its efforts has come from those who do not wish their methods to be bared to the

light of day. There has been talk of abolishing the commission. Never was it more needed than at the present time. Furthermore, its powers should be extended or another agency created to ferret out what has already been labelled as criminal in commercial dealings. Such a federal bureau, in cooperation with the states, private agencies and the courts, should go far to bring the commercial crime situation under control.

As for law enforcement, Gladstone long ago said that "the object of government should be to make it easy to do right and hard to do wrong." Where, despite the law, it is easy to do wrong and evade punishment because of inadequate enforcement machinery, little progress in crime prevention is to be expected. As far back as 1908, Chief Justice Taft, in an address before the Civic Forum of New York City, said:

The administration of criminal law in this country is a disgrace to our civilization. The prevalence of crime and fraud, which here is greatly in excess of that in European countries, is due largely to the failure of the law and its administration to bring criminals to justice. As murders are on the increase, so are all offenses of the felony class; and there can be no doubt that they will continue to increase unless the criminal laws are enforced with more certainty, more uniformity, and more severity than they are now.

What was true in 1908 in this respect is even more true to-day. Law enforcement in the United States is in many respects an absolute farce. And that condition has existed long before and still exists quite apart from the Volstead Act. Court delays and postponements encourage crime. "Because sentence against evil work is not executed speedily," warned the Old Testament prophet, "therefore the heart of the sons of men is fully set in them to do wrong." The lapse of many centuries has not changed in one iota the truth of that statement.

Laxity in law enforcement is reflected by the public attitude. A wider respect for law on the part of the average citi-

zen is a crying need. Better law enforcement and a higher moral tone must be developed hand in hand. In fact, F. Truble Davison, chairman of the National Crime Commission, maintains that "when public opinion becomes sufficiently aroused, the drive against crime will become effective." The commission has dedicated itself "to stimulate public interest and action in the restoration of respect for the authority of the state, in the performance of its fundamental duty of protecting the persons and property of its citizens." As yet the effect upon public opinion has not been encouraging. Instead of more introspection, the result has been in the main a denunciation of exceptionally daring or notorious criminals and the working up of a crime-wave scare. What is necessary is a looking inward on the part of every resident of this country, man, woman and child, and a high resolve—at a time of the year when resolves are in order—that each one will himself be more punctilious in his obedience to law and will frown upon law violations by others. When once the conviction becomes general that the man who endangers the lives of others by deliberately violating traffic regulations or makes it possible for bootleggers to flourish is just as bad at heart as the man who deliberately sets fire to his place of business or sells you worthless securities, there will be less commercial crime, for the moral fiber of the people will then be strong enough effectively to resist it.

Nor is this the millennium to which I am pointing. The American citizen has in many respects already shown himself capable of scrupulous adherence to moral principle. Our intricate credit structure is based upon confidence and good faith. Here we have, together with England, forged far ahead of other nations. Most American business men appreciate the sanctity of contracts and

the importance of honesty in business dealings. What is needed to raise the moral tone of America is simply a further extension of these habits. We live in an age that demands this. In the complicated economic organization in which we find ourselves, we must place confidence in our fellows. No one can possess a knowledge of all the facts upon which his economic welfare depends. He must rely upon others. The danger of being victimized is therefore always present. Lack of respect for laws which aim to protect us in our complex social and business relations is a serious menace. Commercial crime, unless brought under control by adequate federal and state action, proper enforcement of law and high moral resolve on the part of every citizen will in the end destroy our civilization. The fraudulent acquisition of from two to ten thousand million dollars annually represents only the financial side of the situation, bad as that is. But the moral and social decay which this colossal flaunting of law and integrity implies strikes at the very heart of our democracy. If a people can not respect and obey the laws of their own making, possibly Lenin and Mussolini are right. Will government of and by the people perish from the earth when our continent becomes as densely populated as Europe and Asia are now and the Malthusian pressure begins to be cumulatively felt here also? Democracy is still on trial despite America's vaunted prosperity. It will be on trial until our people show themselves sportsmen enough to abide by majority decisions, ethical enough to do habitually unto others as they would be done by, and intelligent and vigilant enough to realize that law infractions, no matter how trivial, and condonation of evil-doing must be vigorously combatted by everyone if our institutions are to survive.

LOCAL CRIME COMMISSIONS; THEIR ORIGIN, PURPOSE AND ACCOMPLISHMENTS

By JAMES M. HEPBRON

BALTIMORE, MARYLAND

INTEREST in crime and criminals is not new. The criminal and his deeds have excited popular interest throughout the ages. Folk-lore, poetry, fiction and the drama have had as their theme some crime or the extraordinary conduct of a criminal. This interest, no doubt, is explained to a considerable extent by our interest in the unusual.

In modern times there has been a growing tendency on the part of the public, the press and fiction writers to make heroes of criminals and to depict them as being hounded by the police and subjected to brutal and inhuman treatment in the form of the so-called "third degree." Stories of innocent people unjustly convicted are given widespread publicity and from one such particular case (if true) the public generalizes. The public attitude slowly changed to one of sporting interest in the criminal. Serious crime increased. The public became more apathetic than ever. Encouraged by success criminals became bolder until to-day in at least one American city we have the spectacle of battles being waged between organized gangs of bandits and rival bands. The police and other law enforcement officers, or in fact any one standing in their way, are looked upon as a common enemy.

The average citizen, at last feeling his own sense of personal security endangered, began to demand that something be done to check the criminal element. Bonding and insurance company rates by this time had reached a new high level. Their tabulation of yearly losses reached staggering sums and those losses were naturally passed on to the public in the form of increased premiums. Suddenly the question of crime and the

administration of criminal justice became a question of vital importance and of frequent discussion by business, civic and professional organizations. The press by this time was filled with discussions of "the crime problem," "law enforcement," "miscarriage of justice" and "abuse of legal process."

Attention was called to the fact that America is an acknowledged leader in other fields, such as medicine, business administration, engineering and the technical arts; why, then, had America not made similar progress with a problem of equally vital interest to society, the efficient administration of criminal justice?

Once public opinion had been aroused to the growing danger of unchecked criminality, all that was necessary to bring about some form of concerted public action in a given community was a particularly atrocious crime which caused an overwhelming feeling of popular resentment. The Chicago Crime Commission was the outgrowth of just such a situation in 1919.

The Cleveland Association for Criminal Justice came into being in a similar way a short time later. The organization of this association, however, differed in that it was preceded by a most thorough and painstaking survey of the administration of criminal justice in Cleveland, which was directed by Dean Pound and Felix Frankfurter, of Harvard University. The published report of this survey is too well known to need comment.

Baltimore late in 1922 was the next city to organize a crime commission. The creation of the Missouri Association for Criminal Justice followed some time

later and was the first association organized on a state-wide basis. The complete survey made by this association has now been published in book form by the Macmillan Company. It is the most thorough and comprehensive study yet undertaken on a state-wide plan.

In the summer of 1925 the National Crime Commission was organized and proposed to give its major efforts to the task of urging states to attack the problem of major crimes of violence in an intelligent manner and offers its services as a clearing house of information for the use of state and local commissions.

At the present time there are already in existence nine citizens' organizations (exclusive of the National Crime Commission) combatting crime. In addition seven state legislatures and governors have acted to control the increase in crime and eleven state bar associations have inaugurated advance movements to decrease crime.

Let us then next consider how these local crime commissions are organized, what they do and what they hope to accomplish. Inasmuch as the Baltimore Criminal Justice Commission is more or less typical of the local crime commissions and since I am naturally more familiar with its organization and work, my remarks will deal more particularly with this commission. It is first of all an unofficial organization composed of twenty-one of the business, professional and civic organizations of Baltimore. It was organized by the Board of Trade, following a particularly atrocious murder, perpetrated during a daylight hold-up and robbery. This crime aroused and shocked Baltimore's citizenry as no single event before or since that time, with the possible exception of the Baltimore fire in 1904. The people of Baltimore were a unit in demanding the prompt capture, speedy trial and conviction of the guilty felons.

The well-organized criminal element of the city, faced for the first time with

a thoroughly aroused public, began tightening its line of defense. Unscrupulous criminal lawyers, alibi, false affidavit and tip-off men, professional bondsmen and even corrupt members of the police department were hard at work.

Several important things happened in quick succession. A carefully planned scheme to thwart the police in the apprehension of the murderers was discovered and as a result Baltimore's most notorious criminal lawyer was convicted of conspiracy to obstruct justice and disbarred. Certain police officials rather closely identified with him were removed. An extra criminal court was opened and the task of clearing a much clogged docket was begun. Several professional bondsmen were convicted of perjury, following which certain new rules regarding the granting of bail were put into effect and rigidly enforced.

An aroused public in "taking stock" of the entire situation decided that something was wrong with the administration of criminal justice in Baltimore. It wanted the facts, and looked to the newly created Baltimore Criminal Justice Commission to supply not only the facts but the solution to the problem as well. First of all the public wanted to know just how much serious crime there was in the city and how many of those crimes were being solved by arrest and conviction, how many of those arrested were dismissed by the police magistrates or handled in the juvenile court, how many were dismissed by the grand jury or whose cases were stotted or nolleprossed by the state's attorney and the number of convictions and acquittals, together with the percentage of cases in which probation was granted.

Was not such information already available and easily accessible? The answer is an emphatic "No." Extended and accurate crime statistics are almost non-existent. Only fifteen of the forty-eight states make any pretense of secur-

ing crime figures. Then, too, where figures are obtainable there is no standardized form of tabulation or terminology.

In making any study of the crime situation in a given community it must be remembered that the administration of criminal justice is a single operation working through a number of agencies. The function of the police is to maintain order and to apprehend offenders. The state's attorney then takes up the thread, unless it has been broken at the preliminary hearing or by the grand jury. Then the courts and the prisons finish the task. Any weak link in the chain destroys the effectiveness of the whole. It is of no use to study any one part of the scheme without relation to the whole.

It is the tendency of each of these various agencies to study this process in terms only of its own function. Thus the police department maintains a set of records by which we learn the number of arrests made and the disposition of those arrested. The grand jury records the presentments and indictments. The records of the state's attorney, police magistrates and the criminal courts show the number of acquittals and convictions and the sentences imposed. Then, too, the probation department, parole commissioner and prisons all maintain separate record systems.

It is quite evident that it is of no great value to know simply how many people are arrested unless we know the proportion of arrests in relation to the volume of crime. Nor is it of any particular benefit to know how many people are convicted without knowing the relation which the number of convictions bears to the number of arrests and the extent of crime. It was found necessary, therefore, not only to coordinate all these existing records but also to go back to original sources for other facts and information.

After all these facts are secured, properly assembled and coordinated it is

possible to see wherein the machine as a whole is failing properly to function. This in turn inevitably leads to certain specialized studies of some particular phase of the administration of criminal justice, as, for example, probation and parole, police methods, use of the stet or nol pross by the state's attorney, the security of bail bonds and an examination of our criminal laws and procedure.

The next step, once we understand the immediate problem, is to keep alive and sustain public interest, realizing that it is impossible to proceed with a problem faster than public opinion will permit. It is frequently necessary to have an overwhelming mass of facts and through those facts mold, direct and change public opinion by overcoming many age-old beliefs and prejudices. Nor is an aroused public opinion of itself sufficient. Organized action is also necessary. Thus in its final analysis it becomes a question of organized public interest versus organized crime.

It is vitally important for a commission to distinguish between the impartial gathering of facts and a mere hunt or "probe" for official wrong-doing. The work should be done in an impartial, even-tempered way. A commission should be neither "hard boiled" nor sentimental but practical and scientific. Its work should at no time assume the nature of a "probe" or "exposé" but should be a practical painstaking study of the entire situation. Every felony case should be carefully followed through from the time of the original report of the crime until the final disposition of the case.

The mere fact that officials know that each case is being carefully followed has in itself a most stimulating effect. The periodical publication of all the facts showing the record of each of the various agencies engaged in the administration of criminal justice tends to create a competitive spirit and almost invariably results in improvement. It is likewise

possible for a commission to bring about a better public understanding and appreciation of the work and handicaps of a particular agency charged with the administration of criminal justice.

"Even if we hasten the process of criminal justice and make our machinery more efficient will this actually reduce crime?" say the more cynical. "Are we not still ignoring the real causes of crime and approaching the question from the wrong angle?" The answer is that an intelligent and efficient administration of criminal justice *does* actually reduce crime. In explaining just why it does reduce crime let us pause for a moment to consider some of the many theories regarding crime. Originally crime was thought to be the result of innate depravity and the possession of the devil. Later the theory was advanced and is still maintained by many, that criminals are a born type, the result of an atavism or throw-back to savagery, and hence are not responsible for their acts. At or about the same time this theory was advanced another school of thought maintained that crime was due largely to imitation. The battle between the differing groups waxed warm. Some time later a scientific investigation was made of a large group of inmates in penal institutions in England to determine whether or not there was actually a born criminal type which could be recognized by definite physical stigmata. The results showed no real variance between inmates of penal institutions and the students of a great English university. In fact there was found to be as much variance between the inmates of different penal institutions as between the students of two different colleges. Thus another theory was shattered by facts.

Unfortunately, however, those making this study fell into the all too prevalent habit of theorizing, by announcing the belief that all criminals were mentally sub-normal. This belief caught the popular fancy and is widely accepted and be-

lieved to-day. Its absolute plausibility accounts no doubt for its so general acceptance.

The lack of scientific knowledge of the norm of intelligence made a real test of the soundness of this theory impossible. It was not until the World War that great numbers of men were given intelligence tests and the norm of intelligence thus more accurately determined. The average of intelligence was found to be much lower than was originally supposed and when our convict population was examined it was found that they received a higher mental rating than did the draft army of the United States, which was fairly typical of our mass population. In this connection it must be borne in mind that the convicts found in institutions represent the lower mental type of criminals, since the more astute frequently escape detection; hence the comparison would seem more than fair to the mass population. It is interesting to note that, generally speaking, the criminals received a higher mental rating than did the guards in the institutions in which the examinations were made.

Therefore, since crime is not due to innate depravity and inasmuch as the Lombrosian theory of a born criminal type has been pretty generally exploded and the sub-normality of criminals proven false, it would seem that actual as well as potential criminals go through the same mental processes as the average citizen. This being true they consider the chances of success or failure of an undertaking just as the average man does. Since the chances of succeeding in a legitimate business are, generally speaking, less than in a criminal undertaking, is it any wonder that those individuals unhampered by character or conscience should choose a career of crime with its greater financial returns and fewer chances of failure?

But by the same method of reasoning, when apprehension becomes more cer-

tain, trial more prompt, conviction of the guilty swift and sure and punishment adequate, professional criminals are brought to realize that the game isn't worth the candle. Crime as a business is like any other business when you take the profit out of it it collapses.

The Baltimore Criminal Justice Commission is one of the local crime commissions which has been a vital factor in doing just those things as far as Baltimore City is concerned. Whereas several years ago only one reported crime in every five or six was followed by arrest now arrests take place in one of every two reported crimes. Cases are tried with a degree of promptness unparalleled in the United States as far as any known records show, as 92 per cent. of the cases tried are tried within three weeks of the date of arrest. Probation, which had been rather indiscriminately granted without preliminary investigation and with little, if any, real "follow up" work, was reduced to proportions within which it could be more properly handled. This action followed the issuance of a report on the subject in which the effects of probation during one year were carefully studied and the results tabulated. The results were undoubtedly disturbing to the complacencies of those who felt content to rest with the formulation of theories. Probation in fact was found to be far different from probation in theory, but it is only through a full and complete gathering and assembly of the facts that a way of betterment is to be found.

It is unquestionably true that existing law is failing to meet new conditions. It has been often said that "legal precepts and processes devised and shaped for pioneer, rural and agricultural society of the nineteenth century are failing to meet the new requirements of present-day America, which is predominantly urban and industrial. The result is growing confusion and uncertainty." England modernized her legal precepts

and processes more than fifty years ago after a succession of exhaustive nationwide surveys by commissions of eminent legal scholars. America, however, continues tenaciously to cling to these old forms of procedure long after the country from whom she borrowed them has discarded them.

In this respect crime commissions can be of tremendous help, and in Baltimore, for example, the Baltimore Criminal Justice Commission brought about the abolition of the antiquated fee system in the state's attorney's office and had set up in its stead the modern budget system. The changing of Maryland's constitution was necessary in order to do this, and those of you who have ever attempted to change the constitution of any state know just how difficult a task this was. Here again the gathering, assembling and presenting of facts was the means by which this change in Maryland's organic law was accomplished.

To summarize, therefore, local crime commissions came into being because of a growing public demand for an improved administration of criminal justice. Their purpose is to reduce crime by making the machinery for the administration of criminal justice more efficient. This is accomplished by knowing and interpreting the facts to the public, by organizing and keeping alive public interest to the end that public action is secured.

This movement is in its infancy. That its growth may be healthy and along proper lines is of the utmost importance. It is profoundly encouraging to know, therefore, that the Harvard Law School has worked out a plan broadly national in its scope, for the purpose of assisting more largely and more directly in overcoming the many serious difficulties now hampering the administration of justice and the conduct of business in this country. Briefly its aims are:

(1) To apply in the field of law the modern method of continuous scientific

investigation which has proved of such practical value in medicine, in business administration and in the technical arts.

(2) To enable trained men of outstanding ability to carry on this important work for the general good under the necessary conditions of permanence and impartiality.

(3) To supply the trained assistants who will be needed by the major investigators.

(4) To make the school's great law library more serviceable to investigators and students.

(5) To make the results of investigation available, as promptly as possible, through publication.

(6) To maintain the highest standards of professional training for lawyers.

Such movements as this point the way to future accomplishments.

STAGES OF EVOLUTION AND RELATION TO CRIME

By Professor LANCASTER D. BURLING

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THE relation between environment and criminal tendencies has had many exponents and they have had an easy task. Somewhat more difficult, however, has been the problem of those who have followed Lombroso in appealing to the predisposing tendencies of hereditary physical traits. We discuss the one and recognize it in our criminal system because we understand it, because science tells us how it works, because it can be remedied. Heredity, on the other hand, we do not understand. Science speaks with certain voice only so far as bodily form and characteristics are concerned. Always there are exceptions, and these increase in number as the objects of our study progress upward in the scale that has genius at the top. Let us see if we can find in evolution a basis additional to those already given by environment and heredity for the science of criminology.

For this purpose intelligence tests seem to offer a valuable starting point. Such tests, founded upon insufficient data and carelessly applied by persons of varying ability to the inmates of our jails and reformatories, led a few years ago to the publication of such statements

as that half or more of our criminals were feeble-minded and that for the majority of these it was hereditary. More mature and based on more inclusive data, later intelligence tests of a comparative character gave different and surprising results. For example, the thirty-three hundred inmates of Leavenworth were found to score slightly higher than ninety-four thousand members of the white draft. Statistics now seem to indicate (Curti) that 15 to 30 per cent. of our criminals have a mental age of eleven or less. But, the average mental age of large sections of the draft was only thirteen, and the obviously feeble-minded were not included. So close a correspondence between the percentages of feeble-minded among criminals and in the adult population of the country as a whole would seem to lead to the obvious conclusions that the criminal is little different than his unlabeled brother and that 20 per cent. of the adult population of our country is feeble-minded. These conclusions various people, Curti among them, have been unwilling to accept. I should like for a while to look with you at the propositions implied by these facts and by many

other things in the world around us if we make the necessary correlations and draw the conclusions to which they point and then to try to apply the knowledge so obtained. Let us do this under the headings:

- (1) All men are born unequal;
- (2) This inherent inequality makes good and evil entirely relative terms;
- (3) We now recognize this inequality in our criminal system, but more or less unconsciously;
- (4) How can our criminals, unequal by nature, be graded;
- (5) How should our criminals, unequal by nature, be treated;
- (6) How can intellectual and moral superiority or inferiority be recognized without sacrificing the democratic principle?

(1) *All men are born unequal*—equality being as accidental, shall we say, as twins. In other words, the effects of environment, which loom so large in our criminology, and the hereditary inequalities to which Lombroso appealed are superficial compared to the more fundamental inequalities of soul growth which are the natural result of the evolutionary process. We do not discuss these inequalities of soul age because we have never considered the subject, because we have been taught to believe that there is no such thing, because science says very little about it, because it seems irremediable. Yet we have always recognized that a genius in music or in art was so born. It displays itself too early to be environmental and too capriciously to be hereditary. Travelling far from the beaten track in central Africa I have found among the natives of a little village the one destined by only a slight stretch of the imagination to become the genius of a later day. He had fashioned a musical instrument finer than, and differing entirely from, the tom-toms of the rest and carried it around with him wherever he went. As there are all grades of musical talent among ourselves is it not a logical inference that it would be possible to find persons occupying all

the steps between the African and Debussy; that Debussy himself must have progressed along such a ladder? And if in music, and in art and in poetry, why not also in intellectuality, in character?

Let us search for the evidence of inherent human inequalities in our own experiences, in such common everyday facts as I have mentioned and in such facts as these:

- (a) The fact of boy and girl prodigies.
- (b) The recognition, by our educational system, of superior types and their accommodation, for example, by "opportunity rooms" with separate teachers in the case of the intuitive children of California, and by honors courses and independent and advanced work supplementary to the regular courses in our colleges.
- (c) The recognition of inferior types in our public school system and the appointment of psychologists to care for them.
- (d) The emphasis placed by educational psychologists upon "individual differences."
- (e) The failure of many grown people to profit at all by the teaching given in the schools for adult illiterates.
- (f) The recognition of the moron and the semi-moron as identifiable members of our civilization—people who can illustrate an ad, play the traps, do any one of a score of things, and can not write a sensible letter. And if semi-morons, why not quadri- or hexi-morons, etc. Nature can not have segregated the particular types of intellectual capacity which children recapitulate at the ages of eleven or fourteen.
- (g) The discovery that large sections of the draft possessed, on the average, the mentality which might be expected of a child of thirteen. Without placing too much credence in the exactness of such figures it is nevertheless possible, with such an average, to appreciate the low figures that will be required to balance the superior figures that must have been present. And, as already stated, the draft did not include the obviously low.
- (h) The fact that punishment, even extreme, does not deter.

- (i) The different stages represented by the person who commits suddenly a crime for which there appears to be no antecedent in the life of the individual and the person who plans a crime. We shall return to this.
- (j) The fact that many criminals feel no remorse for what they have done; the fact that others do.
- (k) The fact that writers, attempting the classification of humanity into groups, have frequently been successful in proving for the members of each group reactions which are characteristic. Such, for example, is the classification and relationships proposed by R. Bennett Bean in the paper on "Human types in relation to medicine" announced for this very afternoon before one of the other sections.

Many other indications of these inherent inequalities will occur to you, and each of the lines of thought listed could be pursued at length. But is this necessary? Men seem definitely to be unequal; are we not ready to accept as a working hypothesis the idea that this inequality may be a variable dependent upon the number of times we have tried this experiment of living? We all differ, the one from the other, as do the older and younger children in a family, shall we say, but are personally responsible for the inequalities which characterize ourselves and our surroundings in the life which we are now living. To select one only of the illustrations already listed, does it not seem as if there could be no better proof that men are on various steps of a ladder of evolution and that many criminals are on very low steps, than the fact that punishment does not deter? The mere thought that an act might be seen or found out would be a sufficient deterrent for many; for others the inhibition would be internal. Are there not two classes, those whom punishment would deter (those farther along on evolution's pathway) and those whom it would not (the child souls); and since both of these are included in the classes from which our statistics are derived may not the resulting conflict in

the data be the reason for argument with men like Lawes and Osborne?

In the world given to us by science, a world in which law and order prevails, in which every cause has an effect, every effect a preceding cause, a world in which energy is conserved and evolution is the keynote, would it not be surprising if there were present elements so arbitrary, so unrelated, so wasteful, so unevolutionary as that men and women have been cast without predisposing causes of their own manufacture into a particular niche of a world wherein there are all gradations from luxury to want, from refinement to coarseness; into a particular body when the range of choice lay anywhere between the perfect and the crippled or diseased; and have been arbitrarily endowed with minds of a certain type when there could have been chosen for them mental abilities ranging from feeble-mindedness to genius? And, are we to believe that the same nature which has spent several hundred million years in the painstaking evolution of everything from atoms to man's body should dispense with this process in preparing souls, or that she should attempt to crowd within the lifetime of each body the evolution of its soul? May there not be a certain recapitulation in the case of the soul and may not we, fairly able to evaluate the rapid changes which take place in the development of our bodily form, be failing to recognize as recapitulation the various steps in the adaptation of an old soul to a new body, an adaptation which, progressive in its nature, simulates the original evolutionary process to some extent and is mistaken for it?

Now, are we not recognizing in our criminal system the fact of inequalities in mental capacity and character, for that is a part of what I mean by soul age? By all means, even if unconsciously, but since these inequalities enter that system when responsible for an act which comes within the criminal

code let us first discuss the inequalities of human beings in the moral field.

(2) *This inherent inequality makes good and evil entirely relative terms.* In ancient India a high caste man was allowed to go or given only nominal punishment in cases where the penalty to a low caste man was severe (Rajagopalan). Up to the nineteenth century Europe made exceptions in the case of the educated, the clergy, the peerage. In the world of to-day where our criminal laws crystallize a code representing the changing morality of the articulate portions of the citizenship, somewhere therefore about halfway between the top and the bottom, there are people at the bottom for whom the laws should be changed, people at the top who are above all laws. It should not be necessary to state that I do not refer to the class which frequently escapes apprehension or punishment, either because its operations are not defined as stealing, for example, or because it is able to build up a workable defense, but to those who would plead guilty if they had even thought of doing that of which they were accused.

Have you ever been in the Texas "panhandle," "out west" where "cow-boys" go down to a domino parlor to spend the evening? Forbidden by law to play pool because of a custom which usually asks the loser to pay for the game, and is therefore gambling, they play dominoes in a hall where all games must be paid for in advance, before winner or loser is determined, and then match fifty-cent pieces to see who pays for the dinner in a restaurant. There I have seen them match coins at a rate which made each chance failure cost the loser as much per second or two as he might have lost in a whole game of pool. Perhaps pool is too slow! My point is that if playing pool (or dominoes) is perfectly proper for those of us who are at a certain stage of evolution, it is more commendable (right) for those who are

below us and might be doing worse, it is less commendable (wrong) for those who are above us and know better ways of spending their time. In other words: A on step 99 of the evolutionary ladder and B on step 101 can both move to step 100; but for A it is a step in advance and commendable, good; for B it is a step backward, evil. Then whether an act be evil or not depends upon the person who does it. Of course, but our realization of the fact should speed up our efforts in the direction of individual punishment.

Let me illustrate further, increasing the range between our actors from the nominal one separating pool-playing and non-pool-playing people to one where the gap is very large. For a starving man to take food is—which? For a nation that does not provide enough money to buy the products of its industry and seeks elsewhere for buyers (as if a theater seating three thousand should print only fifteen hundred tickets—Douglas) to send shoddy to natives in one of its colonies is—which? I have seen a man who was in one of the "outposts of empire" sell a piece of starch-filled calico to a native for \$3.00 and enter \$1.50 in the book of a company which declares large yearly dividends. The native received the \$3.00 for palm oil, and for this payment there was the same kind of bookkeeping, so far as agent's profit was concerned. The agent, the company, the stockholders are engaged in a business enterprise which is called "carrying the flag," "developing the backward races," etc. We do not therefore characterize all stealing as stealing; and many other illustrations will occur to you. But we are interested not so much in the crime itself as in the criminal. He must be on some one step of the previous illustration and his responsibility varies with that position. If he steps downward, from however high, he does wrong; if he lives up to the

light he has and steps upward, from how-
ever low, he does right.

It is a long time since we hanged a man for stealing a shilling. The witnesses of such an execution could not have thought the "criminal" to be a species by himself. Each must have known why that particular man was being hanged. But are we improving? Do we protest? Do we not separate ourselves from the criminal, and are not those of us who are soiled with the same dirt the hardest on him? It was the people who had sinned who had the stones in their hands. We must realize with Sir Basil Thompson, of Scotland Yard, that "the murderer is rarely a criminal by nature . . . he is just you or I." If you and I are at different levels on an evolutionary ladder so are the criminals. Those who are below us stand where we have stood; those whom we are above will some day stand where we are now. Every person, without exception, is treading his own path; and every path across a swamp is a right path if it arrives at the other side. On this path we all make errors. These may warrant our segregation from other people, but they may not be evil at all; indeed they are not if we are doing only that which is to be expected of one at our stage of evolution. Men credit us with vices, but the "vices of men become steps in the ladder, one by one, as they are surmounted." To each of us, "criminal" or not, will come success; "the only possible failure is to cease trying."

(3) *We now recognize this inequality in our criminal system, but more or less unconsciously.* I have added the word "unconsciously" to the heading because I do not see a basic or conscious recognition of the principle of soul inequality in features which make it possible for you to ask me questions such as the following:

- (a) Do we not recognize the mistake of having the same punishment for the same crime committed by different people;

is not individual punishment the keynote of modern penology (Ruggles)?

- (b) How about the failure of juries to convict under the old (and still prevalent) rigid punishment system, even though the verdict is often complicated by an emotional appeal or by the way in which the case is conducted?
- (c) How about the way in which attorneys exercise the right of selecting and rejecting jurors?
- (d) Is it not shown in the growth of the principle that all idea of punishment should be eliminated—that we might as well punish a wolf for not being a setter, a range cow for not being a jersey, a jungle fowl for not being a silver wyandotte?
- (e) Does not the growing sentiment in favor of the indeterminate sentence afford still another instance?
- (f) And the frequent petitions for clemency, how about them?
- (g) What about the distinction we draw between first offenders and the "hardened criminal"? To this I answer with a question: Why is it that the favorable conditions at England's farm prison on the Isle of Wight react so quickly on the "incurables" who are sent there?
- (h) Have not Boehmer and Kretschmer blazed the way with their classification of criminals into asthenic, athletic and pyenic? And may we recall again the fact of the various classifications of humanity in general which Bean reviews in his paper on "Human Types in Relation to Medicine"?

To all these I answer: Exactly. We do have social efforts aimed at the removal of those causes which tend to retard soul growth or to cripple its expression. We have a penal system which is so conducted that soul age sometimes enters the reckoning. We have many thinkers who realize the presence of the inequalities we are attempting to explain. My belief in the originality of my ideas has always seemed to vary inversely with the extent of my information and I should not be surprised to be told that I am merely calling out "Left," "Left," beside a column that has already been placed in motion. Indeed I offer you nothing new; I am

merely using facts already known to you somewhat as a painter uses paints. As I see it, humanity is being constrained to follow a path which does coincide in large measure with realities. It is always thus. I plead for the acceptance, the valuation of these realities, and the development of a criminal system intentionally based upon them and applied to all who come within its field of action rather than that these things should happen by accident; a system that knows the differences and likenesses between the idiot, the imbecile, the lunatic, the moron and the feeble-minded; a system that appreciates the inequalities of mental and moral stature and recognizes them in the making and administration of its laws and in its social reform activities.

(4) *How can our criminals, unequal by nature, be graded?* The gradual evolution of the intelligence test method is making it increasingly helpful, if wisely used, and such tests may well be the basis of a preliminary sorting out of the men even before they come within the operation of such methods as those of the Mutual Welfare League. The necessity that all prisoners shall be so treated and so graded is the essential thing. I offer, however, for the consideration of those among you who can apply it, the fact that a lunatic, hypnotized, becomes intelligent, able to reason, and the possessor of a keen memory; the fact that a man, unlettered by circumstances, will, in trance condition, read Greek fluently, will play a complicated game to which he is a stranger, or will understand and answer in a language unknown to him in his waking state.

(5) *How should our criminals, unequal by nature, be treated?* Mr. Rajagopalan, in his "Growth of Civilization," points out the fact that where one nation is ruled by another there tends to develop in the ruled a half caste group "with power derived from the rulers but with none of their culture and nobility,

a class looked down upon alike by the rulers and the subject race and showing the worst features of both." Realizing that brutality reacts more seriously upon the one who devises it and applies it than upon the one whom we usually regard as the victim, I view with grave concern the growing army of police and detectives, the army of officers in our penal institutions. Run by a staff which is being schooled in brutality, our jails, too many of them, are graduating a stream of students schooled in crime and in nothing else. Our asylums are becoming hospitals; our penal institutions should be universities for the cultural and vocational training of the intellectual, trade schools for the moronic, granting diplomas and union cards. In them should be a field for the keenest of our professors and to them some of the best of our professors will gradually be attracted.

What shall be the first steps in this emancipation? Remove our prison systems from politics, abolish from them all idea of punishment—that of capital punishment in particular, establish self-government, let the men earn their own way and support their families, or earn enough to have families, while they are in prison on an indeterminate sentence, prepare them for graduation into civil life as quickly as possible, and look after them after they are graduated.

Such a program is self-evident; such steps are being taken; they have to be taken very gradually. But I dream of the time when the life lived by the graduate of Sing Sing or Leavenworth, for example, shall make their diplomas valuable, a time when a sentence to such a place will be a real opportunity, a time when criminals incurably dangerous to society will become fewer and fewer, a time when for the others the only disgrace will be failure to so cooperate that graduation will be possible. The officials and the instructional staff of such jails will look for the sources of their own

failure when a man is sent back for a second term. This will not apply to the incurably dangerous, for they will never have been released irrespective of the time which they have spent in the institution.

But let us go deeper. Let us recognize that the acts for which men and women surrender their privilege of going about freely, any acts for that matter, are the final chapters in a cause and effect sequence. The law has for a long time recognized the difference between an act done without thinking and an act planned or premeditated. This is right. Our failure is the requirement, for conviction, that the act shall have been completed. If my information is up to date Scotland recognizes as murder an attempt which would have been murder if death had ensued; France makes a similar recognition in the case of attacks upon public officials; Japan exacts the death penalty for executing or contriving.

It will occur to you that an apparently unpremeditated rash act must have had, during the soul growth of the particular individual, an antecedent mental history which is represented in the present life, or at the moment of commission, only by a predisposition, and that determinism is, therefore, not negated by our hypothesis. As some one must have said: What we were we do, what we think we are. The act represents the fruit of a previous flower; the thought the flower of a fruit that may ripen. Our criminal code pays too much attention to the former (the finished) and too little to the latter (the changeable, the preventable). To the educational jails already described should be sent not only those who succeed in committing criminal acts, but all those who plan or attempt them. We can thus take a step which may stop the criminal sequence of meditated (mental) cause and final (physical) effect before it does any damage on the physical plane and before it

visibly affects others. If to the program we have outlined there is added the impartial application to all, rich and poor, influential and uninfluential, of a criminal code based on the inequality of man and the criminality of attempted as well as accomplished crime our jails, our reformatories, will contain an increasing percentage of individuals with a large I Q, and therefore amenable to an educational process.

Very important also is our share in the guilt of those who fall. We deliberately call attention to pistols as weapons by pasting paper over the extended hand of a man before whom another is falling dead. Impossible, absurd, but true. Our movies depict, before people who live out every detail of the action, express or implied, acts for which our criminal code prescribes penalties; and in cases where the film is not allowed to go this far it shows everything but the actual act. Our novels do the same; our papers spread before a thousand the intimate details of the solution found by some one for the very problems that are confronting them. We are ourselves responsible for the creation of this additional predisposing thought.

(6) *How can intellectual and moral superiority or inferiority be recognized without sacrificing the democratic principle?* We are endeavoring to run our country on the proposition that all men are equal. We have popular referendums, for example, one man one vote, on such questions as (a) permitting an increase in the stock of corporations by a two thirds instead of a majority vote of the stockholders and doing away with the necessity for a sixty-day notice of such a meeting, (b) exempting secondary schools from taxation, (c) taxing short line steam railroads, (d) tax exemption for veterans, (e) restricting the manufacture of oleomargarine. (There were ten other measures and more than twenty constitutional amendments in this particular referendum.) But the

Declaration of Independence merely affirmed certainty that all men were created equal, and a long line of thinkers has stressed the effect of heredity and environment in introducing inequalities. If to these we add the more fundamental inequalities described in this paper democracy bids fair to become the absurdity that it is logically if we look upon it as the final goal. For the purposes of this paper it will be sufficient to realize that if all men were created equal they were probably so created at different times and that they are now equal only in the opportunity that is given to them to grow and to progress upward on the path toward perfection. For this creation took place a long time ago, and the earned advantages and deserved disadvantages of environment and heredity through the ages, as well as in the present, have insured the presence amongst us of souls at all stages of the journey. What solution democracy will find for itself when it realizes the essential inequality of man is difficult to predict. The world has found little fault with monarchy or aristocracy or even oligarchy until they became parasitic. Shall our democracy become so parasitic that it must give way, and if so to what: monarchy, benevolent autocracy, communism, despotism, socialism? Or shall we try a modified democracy based on a classified electorate and run by people who hold office by right of mental and moral stature—a commonwealth in which the strong have duties, the weak rights (Besant)? I do not know.

Just as there is ever an antecedent mental process for every act so is the idealistic program of the 1925 International Prison Conference, for example, an indication of what shall be. So also is our symposium, particularly when it speaks of the future, an augury for that future, and, what is far more important, necessary if that future is to be. The smallness of our room, the fewness of

our numbers, matters not at all. A visitor to our planet some score million years ago, as some one has said, would have found the air, the land and the sea well peopled, and dominated by reptiles of almost inconceivable variety and size. Evolution would have appeared complete, the earth to have no room for anything else. Yet the man of vision would have seen, hiding in the trees, a few small insectivorous animals and could have prophesied that they should give rise to mammals and to man. I have great hopes for the future. Is it too much to hope that you who have been trained in the field of criminology and understand it will attempt to prove or disprove or at least to find out whether or not there is anything of value in, the working hypothesis of a student of evolution.

SUMMARY

Endeavoring to find an evolutionary basis for a newer criminology I have become convinced of the reasonableness of the view that all men are born unequal, mentally and morally, and point out (a) some of the features in our civilization which corroborate such a view and the changes which it introduces into our ideas of good and evil; (b) the fact that criminals usually appear to represent a fair cross section of society, and that we all differ in soul growth, that we are all on different steps of a ladder of evolution which reaches from the bottom to the top with opportunity for all to travel upward to the end; (c) that varying grades of intellectual capacity and moral appreciation have not been fortuitously bestowed, and that such a deterministic view based upon an evolutionary process stretching through the ages is the only one consistent with a world of law and order in which nothing is but in which everything is becoming. I acknowledge that, due to my lack of knowledge, I may be retelling an old story, and that I am merely using facts

with which you are all familiar, the only element of novelty in the paper being the conclusions which it reaches. I acknowledge the presence in our criminal system of the recognition of a fundamental inequality in mankind, but point out its probably unconscious character and plead for its real acceptance as a working hypothesis, introduce into our criminal code, our penal system, our social reform activities. I suggest (a) the possibility of using the psychological methods of hypnosis in determining the soul age of those members of society who are illiterate by circumstance instead of by nature; (b) the gradual conversion of our jails into universities and trade

schools to which some of the best of our professors will come, and the building up of a tradition that shall make wilful failure to graduate and get a diploma a real disgrace; (c) the recognition in our criminal code of the necessary connection between previous thought and subsequent action and the necessity for terminating this sequence before it has an effect in the physical world by sending to our jail-universities those who plan or attempt crime; (d) our own responsibility for a large part of this predisposing thought. Finally I discuss briefly the bearing upon our democratic experiment of the fact of intellectual and moral superiority and inferiority.

IMMIGRATION LAW ENFORCEMENT

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EFFICIENT enforcement of the present immigration laws of the United States is impossible. This is true in spite of the fact that public opinion is convinced of the need for rigid immigration restriction and deportation legislation. Ordinarily it is an easy matter to secure a reasonably strict enforcement of legislation which is so fully in accord with popular sentiment as our immigration laws seem to be. Where dissenting voices are so loud and so frequent as they are in opposition to the Volstead Act common disregard for the law is to be expected. The immigrant problem, however, appears to be different in that the law is popularly approved yet not enforced.

This non-enforcement is in large measure due to exceptional circumstances found in the United States rather than to neglect or inefficiency on the part of the Immigration Service. While it is not within the province of this paper to comment on that service it seems proper to say that the immigration officials have

done their work remarkably well when their financial, geographical, legal and other handicaps are considered. These handicaps will become apparent as our discussion proceeds.

The most obvious problems of enforcement of any set of immigration laws in the United States should be mentioned but require no discussion. They are as follows:

(1) The thousands of miles of United States boundaries, varying in character from swampy seacoast to arid desert wastes.

(2) The opportunities for the maintenance of a high standard of living in the United States which naturally attract multitudes from foreign congested areas.

(3) The millions of aliens already in the United States who by their presence make it difficult to apprehend the illegal foreign resident.

(4) The immense areas of our cities and country districts which afford security to hunted aliens.

(5) The necessity for the United States to do the pioneer work in the field of immigration legislation. No other country has had our problems, though many of the newer lands, such as Australia, Argentine, Brazil, Canada and South Africa, are beginning to meet them on a smaller scale. They have the advantage, however, of being able to look to our experiments for advice on what and what not to do.

Such handicaps as these are no one's fault and can not be avoided. An examination of the legislation itself, however, may show defects or omissions in some measure avoidable. We shall begin our examination by an analysis of the admissibility requirements established by Congress for prospective immigrants.

Prospective immigrants are considered undesirable because of their (a) race or nationality, (b) individual defects of mind or body, (c) personal ideals and conduct, and (d) because of unfavorable economic or social conditions in the United States. Resident aliens may also be deported for reasons of the first three types mentioned. It may be that a share of the enforcement difficulties encountered by our immigration officials lies in the nature of the undesirability tests legally provided.

From the most ancient recorded times it has been good form to judge the merits of an individual by the color of his skin, the shape of his nose, the clothes he wears or even the language he speaks. Foreign characteristics, cultural or biological, apparently significant or obviously unimportant, have been sufficient to classify a man as necessarily inferior. "Barbarian" and "gentile" were rarely intended as terms of praise. This state of mind is as common to-day as ever. Certainly our immigration legislation evidences its wide acceptance by the "barred zone" exclusion of Orientals and the thinly veiled discriminations of the act of 1924 in favor of aliens from Northern and Western Europe.

This attitude of racial discrimination was one of the first important causes of modern immigration law violations, and it is becoming increasingly important as our national pride develops and is written into our alien legislation. Beginning with our timid Chinese exclusion act of 1882, growing more bold with its continuation in 1892 and 1902, and with the extension of the principle of racial exclusion in 1908, 1917, 1921 and 1924, we now say quite frankly that we do not want any Oriental immigrant laborers and only a few others.² We have with growing assurance asserted a belief in our own superiority. As each additional "race" has been put on the undesired list thousands of its members have attempted to smuggle themselves across our borders, and with no little success.

Part of the difficulty here lies in the inability of the "inferior" excluded races to appreciate our point of view. Why should Italians be restricted while Mexicans are allowed in, almost without limit? Why should the Slav with his centuries of glorious history be less desired than the Irish? Why should an American woman lose her citizenship through marriage to a Hindu Oxford graduate but not through a marriage to the lowest African savage? Consequently, the so-called "inferior races" feel no compunction about entering our country illegally, for they are sure that our law is founded upon an error, and while its violation may be a crime, it is to them no moral wrong. So long as

² The following major restrictive immigration provisions show the increasing tendency of the United States to act in accordance with a belief in the racial superiority of its early settlers:

1882—Chinese exclusion legislation

1892— " " continued

1902— " " "

1907—Gentlemen's Agreement limiting Japanese Immigration

1917—"Barred Zone" provision of act of 1917

1921—Quota limitation of act of 1921

1924—More strict limitation of South European immigration and extension of "barred zone" provision to include Japanese

they have an incentive to leave their native lands for ours they will continue to run our borders. No adequate way has been devised to stop them, though millions of dollars have been spent in the attempt.³

Do not misunderstand me. I am not arguing that all races and nationalities should be admitted in equal numbers. There may be biological reasons for their exclusion, but none have been scientifically established in spite of the constant efforts of such students as Stoddard, Madison Grant and Laughlin.⁴

Undoubtedly there are social reasons why the restricted and excluded races should be kept out of the country. Try as we will, however, unless we are willing to spend untold millions on the development of our embryonic border patrol we shall continue unable to apprehend more than a mere tithe of those who attempt entry by evading the inspection which would instantly list them as members of undesired races.

Individual defects of mind or body, like racial characteristics, are relatively easily observable by inspectors at ports of entry. During the fiscal year which ended June 30, 1926, about 300,000 immigrant aliens and 191,000 non-immigrant aliens were admitted to the United States. During the same period some 20,000 aliens were refused admission. The surprising fact is that only a relatively small number of these refusals were based on the more serious physical and psychological defects of the applicants.

³ For illustrations of the increased pressure of potential immigrants created by the quota act of 1924, see House of Rep., Com. on Immigration and Naturalization, No. 69.1.6.

⁴ For evidence in support of this point of view, see: McDougal, "The Indestructible Union," (Especially Ch. 6) Boston. 1925.

Grant, "The Passing of the Great Race," New York, 1916-1919.

Stoddard, "The Rising Tide of Color."

Laughlin, Statements before H. of Rep., Com. on Imm. and Nat., Serials 5A and 1B.

Four hundred and fifty-two applicants were refused admission because they were "physical or mental defectives," while 507 refusals were the result of "loathsome or dangerous contagious diseases." In view of the frequent charges that immigrants are a menace to our native stock, such a report of the immigration commissioner general requires explanation.

The small number of refusals directly charged to disease and other individual defects is partly attributable to the fact that many inferior immigrants denied admission are hidden in such listings as "likely to become public charges," under which heading 3,590 aliens were returned to foreign shores.⁵ Many thousands more of would-be immigrants were prevented from setting sail for the United States by the improved legislation and administration which now provides for foreign inspection in some countries by Public Health Service and steamship examiners, and directs our consuls to deny their visa to obviously ineligible applicants in all countries.⁶ Others, knowing our standards for admission, do not attempt to pass inspection. For these reasons it is difficult accurately to estimate the number of defective and diseased aliens kept from entering our territory.

While such healthy effects of our immigration legislation are to be desired, there is nevertheless one important unsought result, and that is the increased pressure of smugglers on our borders.⁷ We have through wise restrictions on

⁵ Department of Labor, Bureau of Immigration, mimeographed report for fiscal year 1926, released in August, 1926.

⁶ For statistical statement showing more efficient law enforcement resulting from use of "British Plan" of foreign inspection of immigrants, and of consular visa system, see Annual Rept. of Com. Gen. of Im., 1925, p. 2, and H. of R., Com. on Im. & Nat., No. 69.1.6, 1926, pp. 30/31.

⁷ An official summary of the alien smuggling situation can be found in the 1925 Annual Report of the Commissioner General of Immigration, pp. 12-21.

diseased and defective aliens added a large group of potential border runners to those already mentioned in our discussion of the debarred races. This is not an argument for the abolition of physical qualifications for admission, but merely the statement of an evil which necessarily follows their application and makes our immigration laws harder to enforce.

Personal ideals and conduct may also furnish us with desirable standards for the exclusion and deportation of unwanted aliens. A matter of taste, however, becomes involved when we do not want an alien because he believes in anarchism or polygamy or has been divorced for adultery or has been convicted of a crime involving "moral turpitude." One might well consider the impossibility of obtaining an accurate definition which would enable an immigration inspector to determine which immigrants were "anarchists, or aliens entertaining or affiliated with an organization advocating anarchistic beliefs," and therefore subject to exclusion. "Moral turpitude" is a vague term over which officials may well squabble. Adultery, a belief in polygamy, prostitution and other immoral intent are certainly hard to detect, as are several other types of technicalities barring individuals. It may safely be said that any admittance test which amounts to nothing more than a question of personal opinion or the admission of, or conviction for, an "immoral" act, can not be enforced except in isolated instances. This is well demonstrated in the annual reports of the commissioner general of immigration since such provisions have been in effect.⁸

⁸ Well-selected source material from which a good idea of the difficulties of immigration law enforcement, now and in the past, may be obtained, can be found in: Abbott, "Immigration, Select Documents and Case Records," Chicago, 1924, and in "Historical Aspects of the Immigration Problem," Chicago, 1926, by the same author. These include contemporary articles and statistics, court decisions and excellent case records.

During the fiscal year ending June 30, 1925, the following number of aliens were debarred from entering the United States for reasons of personal opinion or conduct:⁹

Anarchists, or aliens entertaining or affiliated with an organization entertaining anarchistic beliefs	2
Prostitutes, and aliens coming for any immoral purpose	55
Aliens who are supported by, or who receive the proceeds of prostitution	1
Aliens who procure or attempt to bring in prostitutes or females for any immoral purpose	42
Criminals	251
Vagrants	11
Professional beggars	2
Paupers	2

In short, while 458,435 aliens were admitted during the year, only 98 who applied were found to belong to what the government terms the "immoral classes"! Only 251 had committed crimes involving "moral turpitude"! Only two were anarchists! The countless pages of Congressional committee hearings and debate, all the public agitation against such dangerous people, have done no more than save us from the attacks of this handful of the unwanted!

Obviously, the law is not being enforced, unless you are willing to assume that Europeans are not subject to the world's vices, as are the citizens of our own country. Of course, the figures quoted do not state the case quite fairly. Many individuals have been deterred from applying for admission by the mere knowledge of our restrictive laws, as was the case in regard to mental and physical requirements. Our foreign consuls have stopped others. Possibly a few other causes of exclusion should be added to our list to make it complete, as, for example, "chronic alcoholism," which kept eight aliens from our arid shores. Reason tells us, however, and so does the

⁹ Annual Rept. of Com. Gen. of Imm., 1925, pp. 152-155.

Immigration Service, that not all of the half million who entered could have obtained admittance honestly.

Social and economic conditions in the United States which may be unfavorable for the admission of immigrants are given slight consideration in our legislation. Immigrants are, on the whole, admitted in bunches, so many of such nationality in a certain period of time. A closer correlation between conditions in the United States and the number and types of immigrants might well make our laws more enforceable, but so little experimental work in this field has been done that we can do no more than express a hope.

Let us now assume for the sake of argument that the legally established tests for admissible immigrants are the best which can at present be devised, and that prospective immigrants are being subjected to them with discrimination. Granting such to be the case, loopholes for illegal entry would still be plentiful in the many exceptions which permit aliens to land in excess of quotas and in some cases after superficial examination.

Alien seamen, for illustration, have been allowed to land for sixty days for the purpose of reshipping for foreign shores. When these seamen decide that their occupational preference lies in the coal fields of Pennsylvania, the mills of Birmingham or the wheat fields of the middle west, it becomes a difficult and an expensive task to obtain their deportation. It is estimated that 38,000 alien seamen deserted their ships at United States ports during the fiscal year of 1924 and about 20,000 during 1925. Many of these have of course left the country. How many we do not know, nor is there any way of finding out. This one loophole in our legislation, however, is considered of such importance by Congress that during 1924 and 1925 over five hundred pages of testimony were taken by House and Senate committees dealing with this problem alone,

and no practical means for stopping the leak were disclosed.¹⁰

For a second illustration of the loopholes in the immigration legislation, one may turn to the quota act of 1924, which, be it good or bad, has as its main purpose the limitation of the number and a qualitative selection of industrial and agricultural workers who may become more or less permanent residents of our country. This purpose is in part defeated by important special exemptions from the normal quota provisions.

It has been indicated that almost a half million aliens were admitted during the fiscal year 1926. Of this number, less than half, or 157,432, were charged to the various quotas. The remainder included 88,758 "non-immigrant aliens" and 249,916 non-quota immigrants. These non-immigrants include such groups as the following:⁴

Temporary visitors for	
Business	19,951
Pleasure	36,663
In continuous transit through the U. S.	25,574
Ministers of religious denominations, their wives and children	1,335
Students	1,920

Such groups present tremendous problems to our enforcement officers, problems which have not been solved and will not be solved except through an increase in governmental employees and expenditures. University officers will tell you how they must constantly be on their guard in admitting foreign students in order to avoid serving as aids in violating immigration restrictions.¹¹ Europeans have heard the call to religious service just as they made up their minds to emigrate to America. A pleasure trip

¹⁰ H. of Rep., Com. on Imm. and Nat., Serial 2B and No. 69.1.5; and Senate Com. on Imm., Hearings on March 18, 1926.

¹¹ There are hundreds of schools and colleges of all sorts on the approved list issued by the Secretary of Labor (see H. of Rep., Com. on Imm. and Nat., Serial 1B, pp. 97-104) and each has its own entrance requirements and general standards. The resulting confusion is obvious.

has many definitions. It is not impossible for an alien to change his status from one of the above groups to a group in the limited class. The job then is to catch and deport him.

The deportation of undesired aliens after they have entered our land is even more difficult than their rejection at the port of arrival. Commissioner General Hull stated in his report for 1925 that "the experience of the fiscal year just closed has demonstrated the accuracy of the statement made a year ago that the deportation of aliens found to be unlawfully in the United States is rapidly becoming one of the most important functions of the Immigration Service." Of the 7,233,595 unnaturalized aliens found in the United States by the census of 1920, possibly 20 per cent. are here illegally.¹² Nine thousand, four hundred and ninety-five aliens were sent out of the country during the year mentioned by Mr. Hull. Ten thousand, nine hundred and four were deported during the fiscal year 1926.⁴ That there are thousands more illegally remaining is admitted by the Immigration Service and by the legislators who drafted the acts now in force, and this fact is accepted by them as a matter of course.¹³

Many of these illegal residents (I do not know what proportion) are such because of their illegal entry. They have sneaked across the border, entered as seamen or passed inspection falsely. Most of them can not now be located except by some such radical measure as a complete alien registration. Our Secretary of Labor has recommended such a provision, and Mr. Hull has accepted it as the only way out of a difficult situation.¹⁴ However, if these aliens have

escaped our boundary guards, how much more tedious and expensive will it be to detect them in our cities and on our farms.

Other aliens have rendered themselves obnoxious while legal residents in our country. Certain criminals, political radicals, paupers, prostitutes and immoral individuals are legally though not always actually deportable.¹⁵ Whatever the merits of such reasons for deportation, adequate enforcement measures have not been provided.

For example, only 412 of the immoral classes and 793 criminals were deported in the fiscal year 1926, though many times those numbers from the millions of aliens in our country have made themselves liable to expulsion for such reasons.¹⁶ I quote from Dr. H. H. Laughlin:

Of course the present law contemplates keeping out of the United States all aliens who are likely to become public charges, but there are so many loopholes in the administration of the law that when one makes a first hand investigation of the custodial institutions of the country he finds many aliens in them in violation of the purpose of our immigration laws, particularly of the act of 1917.

For example, during our survey of 1922 we found in 445 of the larger custodial state institutions in the United States approximately 44,587 foreign-born white persons who entered the United States in violation of the spirit of the law. The reasons they have not been deported are, first, some have been in the United States longer than five years and consequently they are not deportable under present law; second, many of these state custodial institutions, of which there are approximately 700 in the United States, do not feel that it is incumbent upon them to take the initiative in deporting deportable persons.¹⁷

Dr. Laughlin might have added other reasons of practical administration which make it probable that only a few

¹² Jenks and Lauck, "The Immigration Problem," 6th ed., pp. 532-533.

¹³ Annual Rept. of Com. Gen. of Imm., 1925, pp. 159-163.

¹⁴ H. of Rep., Com. on Imm. and Nat., Serial 1B, p. 55.

¹² Annual Rept. of Com. Gen. of Imm., 1925, pp. 9, 12.

¹³ See statements of Mr. Curran, former Commissioner of Immigration at Ellis Island, in H. of Rep., Com. on Imm. and Nat., Serial 1B, p. 12 ff.

¹⁴ Annual Rept. of Com. Gen. of Imm., 1925, pp. 13, 26.

of our present deportables ever will be deported. A simple list of such reasons would be as follows:

- (1) Unwillingness of local agencies to cooperate in the enforcement of a national law.
- (2) The vague legal definition of several causes for deportation, such as the provision for the expulsion of certain political radicals.
- (3) The administrative difficulties of the task of locating, convicting and expelling offenders.
- (4) The expense of the process.
- (5) The necessity for obtaining passports, which may be refused or reluctantly given in deportation cases by such countries as Russia, Turkey, Poland, Germany and England. Arrested individuals may also withhold information essential to the securing of a passport.¹⁸
- (6) The inevitable opposition of public opinion if the law were carried out to the letter.

It is consequently not unfair to say that our deportation legislation is so designed that it can not be justly enforced in regard to even a fair percentage of our illegal residents. On the contrary, it is subject to grave misuse, as are all such blanket laws, for purposes of persecution and political advancement, as was so commonly charged during the régime of a former attorney general. However, in view of the general post-war 100 per cent. Americanism agitation, supported and kept alive by numerous active and powerful patriotic propagandist organizations, there is little likelihood of any real change in the near future.

It is thus evident that whatever benefits have resulted from our immigration and deportation laws (and there have been important benefits therefrom) there are nevertheless unjustifiable violations in spirit and letter which are all too frequent, though unavoidable by the nature of the situation, which permit thousands

of aliens illegally to enter and illegally to remain in the United States.¹⁹

Were we to include the violations of our naturalization laws, which might well be considered an integral part of our immigration legislation, the outlook would be even more dismal. Space forbids such an inclusion. We must turn to a consideration of the means for amelioration of present conditions. Three major suggestions can be offered. They are the usual suggestions offered for the repair of any system of laws which does not function smoothly.

First, we may rely on more and more stringent laws, and an enforcing staff increased in numbers and efficiency. This is the plan which now seems to be in favor with our law-makers, our Immigration Service and the public. It is usually the first and most obvious proposal. A casual reading of Senate and House committee hearings demonstrates the frantic search for laws without loopholes. The Immigration Service is asking for additional men and money. A border patrol has recently been established, and is doing good work, but since its very beginning it has been insisting that it can not do efficient work without additional funds. More immigration inspectors are constantly being requested for our ports and for deportation proceedings. Deportable aliens have admittedly been allowed to remain because money was not available to pay their passage out of the country. There is no end to these requests in sight. If there were, we might feel inclined to grant the wishes of the proponents of this plan. Meanwhile, it might be well to think of the effects of a policy which is resulting in separate national police systems to

¹⁸ H. of Rep., Com. on Imm. and Nat., Serial 1B, p. 13.

¹⁹ Safford, in "Immigration Problems," New York, 1925, shows some of the troubles of Ellis Island officials in a popularly written account of his experiences there.

enforce each separate set of national laws.

Second, there is the possibility of adapting our immigration laws to actualities rather than to pseudo-scientific race theories. This could be done by excluding, admitting and deporting aliens in accordance with their individual qualities, scientifically determined, and with proper regard for the industrial and social capacities of our country. Such scientific tests would supersede our present regulations, which are in part, a rather large part, based on the application of undemonstrated racial and social myths. It is interesting to note that no recognized leading anthropologist, biologist, psychologist or social scientist was called to testify before our Congressional immigration committees in the hearings before our recent legislation on the subject was adopted. Most of the testimony taken was given by people who, regardless of their scientific or practical qualifications, were unquestionably biased. There is little reason to wonder why our laws are not functioning.²⁰

Third, a policy of "hands off" has many advocates who believe in it not only for sentimental reasons but also because they are convinced that natural laws of population alone can solve such problems. As an immediate program this seems inadvisable, if only for social reasons. There is no likelihood of its adoption, for its adherents are relatively few. We should dismiss it from consideration and confine our efforts for immediate improvement to the first two suggestions.

However, it may be well to remember

²⁰ For the quality of the "evidence" presented by "experts" to Congressional immigration committees, see such documents as H. of Rep., Com. on Imm. and Nat., Serial 1B, 2A, Nos. 69.1.9 and 69.1.11 as typical of its numerous hearings.

the possibility that the ultimate solution to our immigration problems may be based on the idea of natural population laws, as the advocates of a "hands off" policy so stoutly maintain.

After all, people do not migrate between countries having equal ratios of resources to population, and in view of the rapid expansion of the United States since the Civil War, it may not be so many years, historically considered, before the motive which is causing these hundreds of thousands of aliens to press upon our shores has disappeared. For the present, we must guard against the relatively temporary troubles which necessarily accompany periods of population adjustment.

Science, not race prejudice, not 100 per cent. Americanism, not economic selfishness, not religious bigotry, not even pseudo-science, must furnish that temporary guard. A few flexible protective measures which are in accord with modern knowledge of race and race relations can now be recommended in general terms. They have, I believe, the merits of the scientific method and of an elasticity which permits adjustment to changing conditions. They will not stop all immigration law violations, for smuggling, at least, will continue regardless of the scientific or unscientific nature of our legislation, as long as residents of other countries have any incentive to come to ours. Improvement should nevertheless result from the adoption of the following recommendations.

First, eliminate the impossible mental and moral desirability tests from the present legislation. As a substitute for the present scatter-shot method, it is suggested that broad powers to exclude or deport objectionable aliens will be given to responsible officials who will act on individual cases rather than blindly follow blanket laws.

Second, immigrants should be selected on their individual merits rather than on a racial or national basis.

Third, the quantity and quality of immigrants admitted should be limited by the economic needs of the United States, determined from year to year by a fact-finding commission.

Fourth, the admissibility of an immigrant should be determined in his home country through the cooperation of the foreign government concerned, our Consular Service, our Public Health Service and possibly the transportation company involved. (This recommendation is now being put into operation.)

Fifth, adequate supervision of resident aliens should be maintained through the cooperation of the federal government with existing public and private agencies, such as hospitals, jails, courts,

police, schools, philanthropic associations, and the like. In view of the multitude of existing social facilities which could be utilized in alien supervision with but little annoyance to the agencies or to the foreign element, it seems worse than useless to establish a cumbersome national immigrant registration system.

Sixth, a governmental program for the social assimilation of the immigrant is badly needed. It could be developed as a part of our fifth recommendation.

These recommendations find little opposition among students of race and population problems and could be of great value in a program for immigration law enforcement. Their enactment, however, will be impossible until the scientific facts on which they are based are known to more than a handful of specialized students.

GRAVITY ON THE EARTH AND ON THE MOON¹

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THE story of Sir Isaac Newton's discovery of the law of gravitation illustrates well the importance of little things. In 1666 a plague was devastating Europe and because of it Newton was forced to return home from the university at Cambridge. He was then twenty-four years old. One day in August while he was sitting in his garden under an apple tree an apple fell to the ground; a commonplace event, but in Newton's mind it raised the questions: "What is the mysterious force that causes the apple and all other bodies to fall toward the center of the earth? Under what law does it operate? Does it pervade all space? If so, it probably varies with the masses involved and inversely with the square of the distance between them." Newton inferred further that the planets are held to their courses around the sun by this same force; likewise the moon in its orbit around the earth.

To test the law he compared the distance through which heavy bodies fall in a second of time at the earth's surface with the distance the moon falls in the same time toward the center of the earth. He found that the moon in its orbit falls toward the earth 1.4 mm in a second, whereas on the basis of his new law he computed that it should fall 1.02 mm in a second; a large discrepancy. He therefore concluded that some other factor must enter the problem to modify the result and turned his attention for the time being to other problems, not realizing that in his computations he had assumed an incorrect radius of the

earth. Sixteen years later he learned of the measurement of a degree of latitude by M. Picard, of France; with the new value he recomputed the acceleration of the moon toward the earth, on the basis of the law of gravitation, and found it to agree with that deduced from the moon's orbit. A year later, in 1683, he communicated his results to the Royal Society and included a dozen propositions on the motion of the planets that had been previously deduced empirically by Kepler from actual observations.

Since Newton's time the subject of gravity and gravitational attraction has been under constant discussion; but there are still many features about which we need information, especially when we consider problems involving gravity as one of the factors.

There are in geology many problems that require for their solution consideration of conditions that are at present beyond the range of our experience. We live on the surface of the earth and we are prone to interpret things in terms of what we see here. To us the mountains are enormous and the oceans are exceedingly deep at certain points. But if we view the earth from a distance we realize that, in comparison with the diameter of the earth, the heights of the mountains and the depths of the oceans are exceedingly small; so small in fact that, if on a globe three feet in diameter the Himalaya Mountains were represented to scale, they would appear to have the thickness of only two postal cards, and the thickness of the part of the earth's crust accessible to us would be represented by a layer of five postal cards.

¹ Lecture given at the Carnegie Institution of Washington on November 27, 1926.

Nevertheless by experiment and by field observation we are learning much about the form of the earth, its interior and its composition. The study of geology is now passing through one of the most interesting phases of its development, and this is due in large measure to the fact that more exact data are becoming available by which the correctness and adequacy of any suggested hypothesis can be tested.

Of the many factors that enter geological problems gravity is one of the most important. It is not only of theoretical interest but also of immediate practical value to certain industries, especially the oil and mining interests.

How is gravity measured? All methods for measuring gravity in the field furnish only relative and not absolute values; they may conveniently be grouped into several classes according to the particular physical property that is chosen for measurement. The quantity to be evaluated is the earth's pull at a given point. The degree of accuracy required is one or two parts in a million.

The method suggested first by Newton for this purpose and the only one that has thus far proved entirely satisfactory is the method based on the free swinging pendulum. In its modern form, it consists of a support on which several pendulums may be swung if desired. Probably the best model is that made and used by the U. S. Coast and Geodetic Survey. Not only must proper supports and proper shaped pendulums be employed; but many factors, such as temperature, pressure, are of the swinging pendulum and the swinging motion of the supports, must be taken into account and proper corrections made for them. The result is that much time is needed to make an accurate measurement of gravity.

Recently Dr. Vening Meinesz, of Holland, has been successful in applying the pendulum method to the measurement of

gravity at sea. For this purpose he uses three pendulums mounted to swing in the same plane. By means of mirrors attached to each pendulum and by allowing light to be reflected from them to a movable photographic sheet he obtains a record of curves that enables him to eliminate the horizontal accelerations of the points of suspension due to the movement of the ship, providing this movement is not too large. Thus far he has made satisfactory measurements only on board a submerged submarine. He has recently travelled across the Atlantic, through the Panama Canal and across the Pacific to the Dutch East Indies and made measurements along the course. These measurements are of the greatest value because of the information they give us regarding the shape of the earth.

The free swinging pendulum method depends primarily on the measurement of time. For this purpose accurate chronometers are used, also radio time signals. At present an effort is being made at the Bureau of Standards to use a tuning fork to serve as an accurate time source in place of chronometers or time signals. If these experiments are successful the time required for a gravity measurement will be greatly shortened.

Another group of methods is based on the elastic deformation either of a gas or of a solid. Of the gas deformation type two instruments have been devised, one by W. G. Duffield and another by L. J. Briggs. In the Duffield type gas is enclosed in a glass chamber and is held at constant volume by maintaining mercury at a definite contact level. Settings are made by altering the level of the mercury in an adjacent column until contact at the given level is just established. In the Briggs apparatus a glass cylinder is filled with nitrogen which is maintained at constant volume by a column of mercury whose height

depends on the weight of the mercury itself, and this in turn on the gravity pull. The temperature is held constant by immersing the entire apparatus in an ice bath. The height of the mercury column is adjusted by bending a small zigzag capillary tubing above the gas cylinder. The chief defects of these types of apparatus are gradual changes in the glass apparatus itself, its sensitiveness to external conditions, such as temperature and barometric pressure, and to the pumping effect when observations are made at sea.

Of the solid elastic deformation types of instruments, three may be mentioned, namely, the quartz thread balance of Threlfall and Pollock, a new type that is being developed at the Geophysical Laboratory, and the Eötvös balance. The Threlfall and Pollock apparatus was developed in the nineties of the last century in Australia. It consists essentially of a very fine silica glass thread or fiber held horizontally between two supports, one of which is rotatable about an axis. Attached to the silica glass fiber at its center is a light cross arm. By rotating one support the thread is twisted and the cross arm is gradually raised to the horizontal position; approximately three complete turns about the axis are required to do this. The angle of twist is read off by a sextant. The position of the end of the arm is observed through a microscope. With this apparatus Threlfall and Pollock carried out some field determinations and concluded that under favorable conditions the values were accurate to better than one part in 100,000, or to 10 millidynes.

In any static apparatus which is to measure to one part in a million a number of factors enter that can not be avoided. Among them are: (1) Lack of perfect elasticity in the materials used; (2) the relatively large effect of temperature on their rigidity; (3) the difficulty

of suppressing vibrations in the elastic system. In the Geophysical Laboratory instrument, which is similar in principle to the Threlfall and Pollock balance, tungsten wire is used in place of silica glass fibers; the damping of the elastic vibrations is accomplished by the use of the tapering spirals combined with the cross arm near its position of horizontality. In this apparatus there is no fixed zero point, the reading being the number of turns required to carry the arm from one position of horizontality to the second. This is of the order of five to eight complete turns. Readings to ten seconds of arc are made or, under these conditions, to about one part in a million. Temperature corrections are eliminated to a large extent by embedding the apparatus in ice. The humidity is maintained constant; also the pressure. One part in a million means control of the temperature to .02° C.

The behavior of the elastic system itself is most remarkable. Hooke's law of proportionality between applied load and resulting deformation actually does not apply to one part in a million but is valid to less than one part in 10,000. When a load is applied the rate of deformation is rapid at first but falls off with the time according to a definite law; under load the deformation continues for days and even years but with ever-decreasing rate, so that after a year it is hardly perceptible. Sir Richard Threlfall has informed me that his silica glass thread after bearing a load for thirty years shows no measurable change even after many days' observation.

This so-called elastic afterworking is, I believe, a surface effect. A surface is one of discontinuity and even though inside a single crystal perfect elasticity may obtain for small loads, at its surface the strains are probably not regularly distributed and give rise to the elastic afterworking. If given time the elastic deformations produced by light

loads no doubt return to the original configuration, at least to one part in a million. Experience with the tungsten spirals has proved that in case of distortion in one direction (say right-handed twist), if the cross arm is raised to the opposite direction the untwisting begins at the point reached by the arm in the first position and so on. In fact the development of the torsion gravity instrument is contributing much to our knowledge of elastic afterworking and of the law it obeys. It is astonishing to find how accurate is the elastic memory of a piece of tungsten wire. It means that in order to obtain concordant results with a method based on the elastic deformation of a solid the observer must follow very closely a definite procedure and adhere to it strictly if an accuracy of one part in a million is to be attained. To work out the most favorable procedure requires much testing and more time than one might think. Suffice it to state that in our tests at the Geophysical Laboratory Mr. England and I are making progress.

Another instrument is the Eötvös torsion balance for the measurement of the horizontal components of gravity. It is in effect a modification of the Cavendish balance. A light aluminum cross beam is suspended horizontally by a long fine platinum-iridium wire. At one end of the beam a metal mass is attached; at the other end an equal mass is suspended by a fine wire. When the instrument is set up, the horizontal pull by a mass of heavy material below the surface is greatest on the nearer lower mass suspended from the end of the beam. The beam is deflected horizontally a measurable amount. Eötvös showed that he was able to measure with this balance extremely small attractions amounting only to 10^{-6} dynes. With it the horizontal components of gravity are ascertainable, also the gravity gradients or changes in gravity with distance in the

N-S and E-W directions; also the difference between the principal radii of curvature of the geoid surface and the directions of the principal sections of that surface; in short, the shape of the geoid surface itself, provided a sufficient number of stations are occupied and the absolute value of gravity is known at one point. The Eötvös balance has rendered very valuable service to the oil companies in this country and abroad in the location of salt domes and other subcrustal inhomogeneities.

We have now described briefly several methods for measuring gravity. Let us, before proceeding to the discussion of the significance of gravity data, take an excursion to the surface of the moon and seek to interpret some of its surface forms in the light of the conditions that prevail there, namely gravity about one sixth of that on the earth and no atmosphere or running water. This is a more difficult task than one might imagine, because we geologists have been accustomed from childhood up to look upon the land forms we see as the result of the action of a number of forces, among which water in its several forms and the atmosphere play a decisive part.

In order to bring our minds to bear upon the moon and its surface features, let us consider first the experience that an artilleryman would have on the moon. Were he to fire a 75-mm gun on the earth his ranges would be between 9,000 and 15,000 yards (5.1 and 8.5 miles) depending on the type of his field piece. On the moon his ranges would be very much greater, namely 230 to 280 miles or more. Were he to fire a Big Bertha, such as the Germans used against Paris during the war, with a muzzle velocity of a mile a second, the range, instead of 75 miles, would be 2,250 miles or over one fourth the distance around the moon. In other words for the same charges the ranges on the moon are twenty-five to forty fold those on the earth.

What is the significance of this extreme dispersion? Consider a volcano in action on the moon. Its materials are hurled into space with velocities like those on the earth; but instead of falling back into the crater as on terrestrial craters they are flung far and wide. The crater floor is left cleaned out down to the molten lava if lava be there. This factor of great dispersion must be adequately considered in any discussion of the moon's surface features. There gravity is so reduced that rocks weigh only one sixth as much as they do on the earth. Everything so far as structural strength is concerned is on a Brobdingnagian scale.

With these relations in mind let us consider the two theories of the formation of lunar craters that have aroused the most discussion, namely, the volcanic and the meteor impact theories. Objection to the volcano theory has been made because lunar craters do not resemble terrestrial craters in detail. I submit that under the conditions that obtain on the moon, one can not expect much similarity between lunar and terrestrial craters. We have not yet established adequate criteria by which we can test the theory of the volcanic origin of the craters. On the other hand, it has been asserted as a strong argument against the meteor impact hypothesis that the craters are almost uniformly circular in outline, whereas one should expect elliptical shapes to be developed by meteors striking the surface at low angles. In the first place, it is not certain that this is mechanically necessary; in the second, when we realize that meteors strike the moon at full speed without retardation by an atmosphere as on the earth, a situation arises that needs investigation. Under these conditions the meteor projectile traveling, say, 10 to 20 km per second on impact penetrates some distance into the moon's crust, sets up an aureole of intense compression which re-

bounds elastically and ejects some material. Moreover, by the abrupt stopping of the meteor its kinetic energy of translation is available both for mechanical deformation and for conversion into heat sufficient to melt the meteor itself and the adjacent rocks, to set free occluded gases and even to volatilize some of the material, thus producing an explosion analogous to a volcano in its action. In case the meteor were to penetrate deeply to a molten layer of rock a real volcano would result. In either case the original shape of the crater would be much changed by the action of forces set up by the impact. The circular shape of the craters on the moon may not be therefore construed as an argument against the meteor impact hypothesis. More data are required before a definite decision can be arrived at regarding the mode of origin of these craters, to say nothing of other perplexing features on the moon.

Returning now to the earth we find that its surface, like that of the moon, is also irregular with mountains and ocean deeps. The question arises, "How are these mountain masses sustained? Why do they not spread out and become flat like the plains?" Geologists have observed that the land, which we consider to be so stable, has in the past risen and sunk repeatedly, also moved laterally, so that at many places rocks originally in horizontal beds are now folded, tilted and crumpled as though there the earth's crust had been shortened by very appreciable amounts. What have been the causes of these movements, both vertical and horizontal?

Geologists realize that in problems of this kind we are considering conditions beyond the range of our experience and we seek primarily to gather all possible facts that bear on the problem so that in the light they shed we can test this and that hypothesis. We must expect the advancement of all sorts of hypotheses

to account for the observed relations and realize that in the present development of the science no single hypothesis is entirely acceptable. One of the most important facts bearing on these problems is that expressed by the term *isostasy*.

Three quarters of a century ago it was found in Northern India by triangulation that the difference in latitude between two places *Kalianpur* and *Kaliana* was $5^{\circ}23'42.294''$, whereas the astronomical observations, referred to the plumb line as zenith, showed a difference of $5^{\circ}23'37.058''$, a discrepancy of $5.236''$ between the two methods. *Kaliana* is only sixty miles south of the Himalayas, and it was thought that the attraction of the mountains had affected the plumb line. But Archdeacon Pratt proved on calculation that if the average density of the Himalayas were 2.75, the discrepancy should have been $15.885''$, or three times that actually found. Sir George Airy suggested in 1855 that the mountains must therefore be supported from beneath and are, as it were, floating on a denser substratum as a log or an iceberg floats in water. The iceberg, with a density less than that of water, extends downward into the water to a distance such that the mass of the displaced water is exactly that of the berg. Hence the attraction due to the berg on a plumb line set up some distance away would offset by the attraction, in the opposite direction, of an equal mass of ocean water and there would be no appreciable deflection. To quote Airy:

I conceive that there can be no other support than that arising from the downward projection of a portion of the Earth's light crust into the dense lava; the horizontal extent of that projection corresponding widely with the horizontal extent of the tableland, and the depth of its projection downwards being such that the increased power of flotation thus gained is roughly equal to the increase of weight above the prominence of the tableland. —It is supposed that the crust is floating in a

state of equilibrium. But in our entire ignorance of the *modus operandi* of the forces which have raised submarine strata to the tops of high mountains, we can not insist on this as absolutely true. We know that it will be so to the limits of breakage of the tablelands; but within those limits there may be some range of the conditions either way. It is quite possible that the immersion of the lower projection in the lava may be too great, as that the elevation may be too great; and in the former of these cases the attraction on the distant stations would be negative. Again reverting to the condition of breakage of the tablelands, it will be seen that it does not apply in regard to such computations as that of the attraction of Schehallien and the like. It applies only to the computations of high tracts of very great horizontal extent, such as those to the north of India.

Archdeacon Pratt objected to Airy's flotation hypothesis on the grounds that it postulates a comparatively thin crust; that the crust is lighter than the liquid substratum on which it floats; and that, just as a protuberance outside the thin crust is accompanied by a protuberance inside down into the liquid, so a hollow, such as occurs in deep seas, postulates a corresponding hollow beneath it; this leads to a law of varying thickness which no process of cooling could have produced. Pratt suggested in 1859 and 1864 that:

Below the sea level under mountains and under plains there is a deficiency of matter, approximately equal in amount to the mass above sea level; and below ocean-beds there is an excess of matter approximately equal to the deficiency in the ocean when compared with rock; so that the amount of matter in any vertical column drawn from the surface to a level surface below the crust is now and ever has been, approximately the same in every part of the earth.—In order to attack this problem mathematically it is necessary to assume some law of distribution of the mass, that the calculation may be possible. I assume that the deficiency or excess of matter is distributed uniformly to a depth bearing a fixed ratio to the height of the land or the depth of the ocean. The actual distribution most likely differs from this. But this is taken as an average. We must expect, for these reasons, to find that the hypothesis is not satisfied with exact precision.

Archdeacon Pratt's main hypothesis accounts, then, for the development of surface features as due to the vertical expansion of columns of rock down to a certain depth; the expansion is the same at all points of the same column, but differs from column to column. In other words, below mountain areas there is a deficiency of mass down to a certain level, while under the oceans there is an excess of mass down to the same level at which level the pressure is practically uniform in all directions. In his later paper of 1871 Pratt mentions other causes that affect crustal conditions:

As the crust contracted and brought into play the prodigious force of compression, which would inevitably cause the crust to give way at the weakest part and produce anticlinal lines, crushing, sliding and interpenetration, there would be a slight increase of mass in some parts on this account.

Both Airy and Pratt recognized that the compensating cause must be looked for in a deficiency of matter below elevated land areas and an excess of matter below ocean deeps. Pratt especially refers repeatedly in his papers to the higher densities of sub-oceanic rocks. The two writers do not agree, however, on the mechanism, by which this state of equilibrium or balance is attained and maintained. The two hypotheses are still under discussion and final decision regarding their relative merits has not yet been reached. Notwithstanding this uncertainty regarding its mode of operation, the facts of geodesy and geology do show that this theory of isostasy, as it was first called by Dutton in 1889, is valid and that the earth's crust rests approximately in equilibrium upon a heavier substratum that yields slowly to stresses and acts over the span of geologic periods as though it were a liquid. On this theory large elevated areas are raised because, like the icebergs, they are of lighter material than the adjacent lower lying masses and float in equilib-

rium on the subjacent heavier layer. Conclusions of this character were drawn by Pratt from a series of pendulum observations made in India in 1865.

Dutton defined isostasy as follows:

If the Earth were composed of homogeneous matter its normal figure of equilibrium would be a true spheroid of revolution; but if heterogeneous, if some parts were denser or lighter than others, its normal figure would no longer be spheroidal. Where the lighter matter was accumulated, there would be a tendency to bulge, and where the denser matter existed there would be a tendency to flatten or depress the surface. For this condition of equilibrium of figure, to which gravitation tends to reduce a planetary body, irrespective of whether it is homogeneous or not I propose the name *isostasy*.

In discussing the subject further Dutton notes that in areas in which deposition is taking place subsidence is the rule, while in regions where erosion is active, elevation predominates. To quote further:

It seems little doubtful that these subsidences of accumulation deposits and these progressive upward movements of eroded mountain platforms are, in the main, results of gravitation restoring the isostasy which has been disturbed by denudation on the one hand and by sedimentation on the other. The magnitudes of the masses which thus show the isostatic tendency are in some cases no greater than a single mountain platform less than 100 miles in length, from 20 to 40 miles wide and from 2,500 to 3,500 feet mean altitude above the surrounding lowlands.

In his paper Dutton does not specify a definite thickness for the crust. Reasoning as a field geologist he infers that, coupled with the lateral transfer of material on the surface of the earth, there must be subcrustal transfer of material in the opposite sense. He affirms:

Whenever a rise of land occurs one of two things has taken place; the region affected has either gained an accession of mass or a mere increase in volume without increase of mass. We know of no cause which could either add to the mass or diminish the density, yet one of the two must surely have happened. But the difference of the two alternatives in respect to

consequences is immense. If the increase of volume or an elevated area be due to an accession of matter, the plateau must be hoisted against its own rigidity and also against the statical weight of its entire mass lying above the isostatic level. But if the increase of volume be due to a decrease of density there is no resistance to be overcome in order to raise the surface. Hence I infer that the cause which elevates the land involves an expansion of the underlying magmas and the cause which depresses it is a shrinkage of the magmas. The nature of the process is, at present, a complete mystery.

Previous to the publication of Dutton's paper, geodesists in Europe especially had taken great interest in this problem because of its bearing on the larger problem of the exact figure of the earth and had developed several different methods for comparing the observed values of the deflection of the plumb line and also for gravity with those deduced from the theoretical spheroid of rotation. The first method was due to Bouguer in 1749; in his reduction of gravity values account is taken of the height of the observation station above sea level and also of the rock mass between it and sea level. His formula is based on the assumption that the crust is strong enough, without deformation below sea level, to support loads above sea level; the assumption is also made, but for computation purposes only, that the rock mass between any station and sea level is in the form of a horizontal plate extending indefinitely and of average surface density. This formula resulted in anomalies roughly proportional to the height of the station, and becoming quite large in elevated regions. This result naturally led to the *free air reduction method*, in which the mass of the mountain is disregarded altogether, and correction is made only for height above sea level. While this method largely eliminated the anomalies in elevated level regions, it gave results in mountainous regions sometimes even more discordant than those with the

Bouguer formula, the anomalies having a distinct relation to the height of the station above or below the surrounding region. While the free air reduction is a crude application of the idea of isostasy, it has been shown that it overcompensates for a station above the average level of the region, and undercompensates for a station below the average level.

The theory of isostasy, as expressed by Dutton from a geologist's viewpoint, aroused much discussion. In the United States the first serious effort to test the theory was made by Dr. George R. Putnam in 1894 and 1895, while he was a member of the U. S. Coast and Geodetic Survey. He determined the relative force of gravity at thirty-eight different stations, widely distributed over this country, and reduced these and twenty-nine earlier observations on coasts and islands, by a method which he called the Faye or *average elevation* reduction method, but which was actually a new method devised by him and a great improvement over the *Bouguer* and *free air reduction methods*. Instead of subtracting the attraction due to the entire mass between the station and sea level or of disregarding it altogether, Putnam considered only the attraction of a plate of thickness equal to the height of the station above or below the average elevation of the surrounding topography within a radius of one hundred miles. In addition Putnam applied a correction for departure of the topography about a station from that of a horizontal plain, following the customary practice of subdividing the region into zones and compartments, where this topographic correction was appreciable. The values obtained by Putnam by this simple method accord remarkably well with those obtained much later by Hayford by a more complex but theoretically better method. Putnam inferred from his measurements and computations that:

The results of this series would therefore seem to lead to the conclusion that general continental elevations are compensated by a deficiency of density in the matter below sea level, possibly in much the same way that the portion of an iceberg standing above sea level is compensated by the difference in density of ice and water below the surface, but that local topographical irregularities, whether elevations or depressions, are not compensated for, such irregularities being maintained by the partial rigidity of the Earth's crust.

His conclusion is that there is a fairly close condition of isostatic equilibrium; that the departures from perfect isostasy indicate that single mountains may be supported as extra loads on the earth's crust; but that these local loads are to be considered as regionally compensated.

Quite independently of Putnam, G. K. Gilbert, in discussing the significance of Putnam's results, adopted a reduction, similar to that employed by Putnam and called by him a *reduction to mean plain*, but he used the average elevation within thirty miles of the station instead of the one hundred-mile limit adopted by Putnam. Gilbert obtained anomalies similar to those derived by Putnam, but materially larger. He concluded from his results that "the whole Rocky Mountain plateau regarded as a prominence on a broader plateau, is sustained by the rigidity of the lithosphere." This conclusion was modified by Gilbert in 1912 in the light of later data to accord with the position taken by Putnam.

The next investigator in this country to consider isostasy was J. F. Hayford. His contributions are of the greatest importance and included investigations not only into the deflection of the plumb line and its bearing on isostasy and the figure of the earth, but also into the isostatic compensation of topography and its influence on the intensity of gravity. Dr. W. Bowie collaborated with Dr. Hayford in the gravity work and has carried it on independently since their joint paper of 1912. The work of these two men, together with that of the

geodesists of India and of Helmert in Germany, has established the theory of isostasy as a fact fundamental in the development of the surface features of the earth.

Hayford realized that gravity is universal in its action and in his treatment of the problem included the entire surface of the earth. He adopted the Pratt hypothesis of density deficiencies and excesses in columns down to a certain level; continents exist because the crust underlying them is composed of relatively light material; the floor of the ocean is depressed because the crust below is composed of dense material. He prepared a practical and workable scheme for computing for any given station the gravity effects produced by the masses distributed over the entire earth's surface down to an isostatic depth that he was able to ascertain by computation. In this work a definite surface of reference is used and the value of computed gravity or deflection of the vertical for a given station is compared with the observed value. The difference between the observed and the computed values is called the gravity anomaly.

In his extended report in 1909 in which deflections of the vertical were used Hayford considered several different distributions of isostatic compensation, namely, uniform compensation extending to a depth to be determined; compensation concentrated chiefly at the surface and decreasing downwards; compensation restricted to a layer of given thickness, say ten miles, and buried at a depth to be ascertained. The sets of computed deflections, obtained on the basis of these different assumptions, agreed so closely that their differences were much smaller than the accidental errors. He also considered the floating crust or Airy hypothesis and found that if twenty-five miles be the thickness of the crust below areas which are at sea

level, then beneath mountainous areas, such as Nevada, Utah, California, the thickness of the crust should be thirty-eight miles and all the isostatic compensation should occur between the depths twenty-five and thirty-eight miles below sea level. Therefore, the mean isostatic depth under mountainous areas should be greater than under areas only slightly above sea level. Hayford concluded that, because his data indicated a greater depth of compensation for the latter areas than for mountainous areas, the floating crust or Airy hypothesis is not valid for the United States. More recent data, especially by Bowie, prove, however, that the depth of compensation under mountainous areas is probably greater than under areas only slightly above sea level. Hayford's objection to this hypothesis is therefore no longer valid.

The hypothesis finally adopted by Hayford, namely, that the earth's crust is in a state of perfect isostasy with each topographic feature, however small, compensated by a deficiency or excess of mass directly underneath it, appeared to him to be the most plausible and at the same time was the simplest to treat mathematically. In his earlier investigations he found the most probable isostatic depth to be 113.7 km; in subsequent work he derived from the deflection data the value 122.2 km. Later work by Bowie has shown that in this country the more probable value is about 95 km (59 miles) as derived from gravity data in mountainous regions; when all the stations of the United States are used, many of them over plains and coastal regions, a lower value, 60 kilometers (37 miles), was derived, but this value is less certain than that obtained from the mountain stations.

Computations by other geodesists and by other methods have led to about the same or smaller isostatic depths.

The features of uncertainty in the

theory of isostasy are no longer the fact of isostasy itself, but rather certain details and in particular the mechanism of the process. Colonel Burrard, of the Indian Geodetic Survey, has aptly said:

Geodesy has produced much evidence in favor of the view that the condition of isostasy exists throughout the Earth's crust, but it has produced no evidence of the process by which isostatic readjustments are constantly being made. Geodesy teaches that in a region where an extra load of rock is accumulated, the underlying crust decreases in density and whenever rock is removed or eroded the crust underneath increases in density. I, therefore, conclude that the condition of isostasy is brought about by the force of gravitation acting upon a crust, the structure of which is not understood.

Before discussing these details let us consider briefly what we know of the crust of the earth down to a depth of say sixty miles.

(1) In the first place the distribution of gravity anomalies proves that whatever is the cause of these anomalies, whether extra loads supported by a competent crust, or inhomogeneities in densities of buried rock masses near the observing stations, they are local in character and near the earth's surface, within one hundred kilometers probably.

(2) The study of earthquake waves and their propagation has proved that at a depth of 60 km the velocity of propagation is that characteristic of an ultrabasic peridotite, such as dunite, and not that of a gabbro or granite.

(3) The depths of the centers of earthquake disturbances rarely exceed 40 km, according to Mohorovicic.

(4) The thickness of the radioactive granite layer, on the assumption that radioactivity either falls off exponentially or is distributed uniformly through a layer of finite depth, has been shown by Jeffreys to be about 16 km.

(5) The great outpourings of basalt over vast areas of the continents indicate that not far below the surface at these points there is a layer of basaltic com-

position heated to a temperature approaching the melting region.

(6) The compositions of the first ten miles of the earth's crust have been ascertained by Dr. H. S. Washington by computing the densities from chemical analyses of collections of rocks from different parts of the world. The results of his labors prove definitely that continental rocks are lighter than ocean basin rocks; in particular that the average density of the igneous rocks of a region varies in the opposite sense as the average altitude. By taking into consideration elevations and assuming that the average rock densities for each elevation are maintained relatively down to a given depth of equal pressure for all surface elevations, he finds the depth of this *isopiestic* level, as he calls it, to average about 59 km.

(7) From the data of the average elevations of continents Joly has computed, on the assumption that granite of density 2.67 rests on basalt of density 3.00, a thickness of 31 km for the granite layer.

All evidence that we have gathered indicates that at a depth of 30 to 60 km a rather rapid change in rock composition and in density occurs and that as we go down from the surface the rocks become more and more basic and heavier and that the temperature rises.

To summarize we may state that whatever be the mechanism which causes isostasy to function, it is confined essentially or chiefly to a layer 100 km more or less in thickness; the departures from isostasy are essentially local in character, probably covering areas one hundred miles square more or less.

We come now to the consideration of the mechanism by which isostasy is or can be attained. From the time of Hayford geodesists have adopted, partly because of ease of computation, the Pratt view, namely, that surface irregularities are compensated by a deficiency

or excess in density in the column directly below the surface feature. This leads to the determination of a definite isostatic level at which all columns of the same horizontal cross section extending to the surface have equal masses.

At the present time it is a serious question whether the Airy flotation hypothesis of compensation at lesser depths, usually about one half of the depths obtained by the Pratt method, does not represent the situation more correctly than the Pratt compensation hypothesis.

One of the reasons why geologists have found it difficult to accept the theory of isostasy in the form stated by Pratt is the assumption of a mysterious expansion or contraction of the mass directly below a given surface feature, such as a mountain mass, in order so exactly to compensate for the shift of load. There is something unnatural about this assumption, as geodesists themselves have admitted. The question arises: Are the differences between the theoretical and observed values of gravity eliminated as well by the Airy theory? A recent paper by Heiskanen, of the Geodetic Survey of Finland, seeks to answer this question. For the purpose he compares the results obtained by the Pratt and by the Airy methods under different assumptions for seventy-one stations in the Caucasus; for forty-seven stations in Europe; twenty-seven stations in the Alps; sixteen stations in Italy; eleven stations in Spitzbergen, and fifty-six stations in the United States. For the United States he finds that the Airy hypothesis on the basis of a crustal thickness of 50 km accounts somewhat better for the gravity values than does the Pratt hypothesis. For the Alps the crustal depth is 41 km; for the Caucasus 77 km; for Southern Norway 32 km. In general his results show that in many regions there is not so much to choose between the two hypotheses and

that neither the depths of compensation of the Pratt hypothesis nor the crust thicknesses on the Airy view are the same the world over, but are different in different areas.

Still more recently, Jeffreys has considered the two hypotheses and, by treating the general problem by the methods of spherical harmonics applied to the gravitational potential, has ascertained that for wave lengths or distances between a maximum positive value and a maximum negative value exceeding 100 km there is little to choose between the two hypotheses; that the distinction might be made for shorter wave lengths, but these do not appear to exist; that therefore a given Pratt isostatic depth is equivalent to an Airy compensation of about half that thickness; "that the uniform compensation of the Pratt hypothesis to a constant depth is observationally equivalent to compensation concentrated at half that depth which is approximately what is implied on Airy's view; that the decision as to whether the compensation conforms to the Pratt type or to Airy's or whether its horizontal distribution is local or regional, can not be made by geodetic means, but requires an appeal to physical and geological considerations." In other words, geodetic measurements alone are not competent to decide between the two hypotheses.

The fact that the Pratt hypothesis considers primarily expansion or contraction of volume accompanied by little horizontal crustal movement accounts well for mountain uplift, but it does not explain folding and thrusting such as is observed on a large scale in so many parts of the world. The maintenance of isostasy during mountain formation and the lateral shift of materials at the surface are not adequately explained by this hypothesis. Recently Dr. Bowie has suggested that during uplift and mountain formation chemical and physical changes take place in the underlying

rock masses that cause expansion; but in a physical-chemical system subjected to load or external pressures the law of Le Chatelier states that we should expect under those conditions physical-chemical changes within the system itself to take place in the opposite direction, namely, changes that tend to contraction and to an escape from the load. It is difficult to imagine changes in mass, such that, for example, after the formation of a delta the density of the loaded prism should decrease, unless it be through expansion on heating or through an increase in volume occasioned by melting or by the release and expansion of volatile components.

If we concede small finite strength to the underlying crustal material Airy's hypothesis or mechanism apparently stands the test better. It involves only generally accepted mechanical principles and is consistent with a compensation uniformly distributed through a finite depth, but a depth varying as the surface elevation varies. Hayford showed that the same distribution of gravity values can be obtained by assuming either uniform distribution of the abnormality in gravity in depth or concentrated at a given depth near the surface.

Jeffreys has considered whether the compensation is locally or regionally distributed, and finds that in a region of deposition or increasing load the deformation should occur at first just outside and along the margins of the loaded area; the compensation will therefore be regional. The same holds true for areas of denudation. This corresponds with the view reached years ago by Putnam, Barrell, and still earlier by Airy. Jeffreys' general conclusion, based on geological and physical grounds, is that the Airy flotation hypothesis meets the situation somewhat better and permits not only vertical but also horizontal movements and hence folding and

thrusting on a large scale, without serious disturbance to isostasy.

A weakness of the Airy hypothesis is the assumption that a crust, weak enough to be in isostatic equilibrium, is still competent to transmit thrusts great enough to form mountains with the accompanying compensating projections below and to maintain these projections in the hotter and weaker subcrustal region; also that an area of deposition, such as a synclinorium, which implies an increase in density in the underlying crust to provide for the progressive settling of the basin, should be maintained for a long period; and then later, as a result possibly of expansion due to heating, melting and release of volatile components, should become a mountain region in which the effects of tangential compression and thrust, as well as those of vertical uplift, are clearly shown. This objection to the Airy hypothesis is, however, not confined to it alone, but applies to all the hypotheses that have been proposed to explain the mechanical problem postulated by isostasy.

Data gathered by geodesists on the horizontal components of gravity (deflection of the vertical) and on the acceleration due to gravity (pendulum data) prove that the actual figure of the earth (geoid) approaches very closely to that of the theoretical spheroid of equilibrium; the departures from this surface of equilibrium are expressed by the gravity anomalies and these are found to be small. This condition of approximate equilibrium is, in effect, the meaning of the term isostasy, as proposed by Dutton; namely, a tendency toward a figure of equilibrium in the shape of the earth despite the many factors, such as erosion, deposition, earth movements, volcanic action, that tend to disturb the equilibrium. Isostasy is a fact, and the close approach of the figure of the earth to a spheroid is the expression of this fact. The crust responds to the disturbing fac-

tors by adjustments within itself that tend to offset these factors and to restore the isostatic balance and figure of equilibrium; from this we infer that the crust is mechanically weak with respect to superimposed loads. The fact that gravity anomalies, even though small, persist the world over and throughout areas in which the rock masses are relatively homogeneous, proves, however, that the crust has some residual strength of a local nature.

Geologists have observed in many parts of the world the effects, in rock masses, of thrusting and folding on an immense scale; this indicates the action of large horizontal or tangential forces; and this in turn requires for its operation a crust of no small mechanical strength.

We are thus confronted by an awkward situation. It is difficult to reconcile the idea of a crust that, at one and the same time, is weak with respect to vertical forces (loads), but is sufficiently strong to transmit horizontal thrusts of great magnitude and to store up energy as energy of compression. We know from earthquake phenomena that stresses of appreciable magnitude do accumulate in the earth's crust and that, when the stresses in the heterogeneous rock masses become equal to the breaking strength of one of these masses, rupture may take place and an earthquake result; if the weak member is spread over a wide area and subjected to somewhat different conditions of stress, the rocks may yield by flowage and relatively slow movement. It is these two opposing characteristics of the earth's crust, isostasy and the ability to transmit horizontal thrusts, that geologists and geodesists encounter and have not yet been able to incorporate into a mutually satisfactory geological theory. The chief reason for this difficulty is our very inadequate knowledge of the behavior of materials under the conditions that obtain in great het-

erogeneous masses at depths within the crust and over long stretches of geological time.

It serves no useful purpose for geologists to deny or to ignore the fact of isostasy; nor for geodesists to brush aside the fact of horizontal thrusts on a large scale. With respect to the two main hypotheses, the Pratt and the Airy, to account for the isostatic adjustment or control, it is probable that both hypotheses are correct in part and that the factors postulated by both hypotheses are of importance. In addition, other factors may enter the problem of which we have little knowledge. The problem is so large and has to do with such heterogeneous materials and diverse conditions of pressure and temperature that we can not expect a single hypothesis to cover adequately all the possibilities that may arise. What is needed is more detailed information regarding the mechanical properties of the materials of the crust. This information will be gathered only slowly and by careful observations in the field and in the laboratory.

It seems to me that a critical test between the Pratt and the Airy hypotheses might be obtained from seismograph records. On the Airy hypothesis the dense peridotitic layer under high mountain areas should be depressed more than it is in ocean basins or seaboard regions; on the Pratt hypothesis the depth to this layer should be more uniform the world over. With the gathering of more gravity data and possible accumulation of short wave data a further test should be possible.

Jeffreys has shown in his book on the earth that the greatly increased age of the earth, as deduced from radioactive surface heating, means that the contraction theory is more than able to account for all the crustal shortening involved in mountain formation, past and present. This factor, coupled with the Airy theory of isostasy, gives to him a satisfac-

tory explanation of the several types of mountain formation.

Still a different explanation is that offered by Joly in his recent book on "The Surface History of the Earth." Accepting the Airy version of isostasy as a fact he seeks to provide the mechanism for keeping isostasy in action by the disturbing effects produced by the radium content of the rocks. He defines isostatic equilibrium as connoting a true flotation of the continents in a substratum of basaltic character, this substratum being for the greater part overlain directly by the oceans. He assumes further that the quantities of the radioactive elements, uranium and thorium, found in the continental igneous rocks are valid for all continental rocks and that the uranium and thorium content in the plateau basalts indicates the radioactive state of the substratum. He considers the continental crust to be about 31 km thick.

As heat from the radioactive transformations increases and is stored up in the lower part of the crust which is near the melting temperature, its temperature is raised and actual melting takes place with consequent radial expansion of appreciable magnitude. The radioactivity is greater under the granitic continental areas than under the oceans. As melting proceeds the ocean crust becomes so thin that tidal action becomes important and currents are set up in the molten subcrustal basalt such that the hotter magma from beneath the continental areas exudes as it were along the eastern margins of the continents, especially Asia, in their general drift from east to west. This east-to-west movement with excess heating and extrusion and intrusion of vast quantities of magma, together with crumpling of the crust along weak, thin crust areas, is considered by Joly competent to account for the surface features of the earth and at the same time to do no violence to isostasy.

After a period of intense volcanic and mountain activity the suboceanic superheated areas cool down slowly, say for 5,000,000 years, after which a new period of heating extending from thirty to sixty million years begins. It is not feasible here to examine further into the details of Joly's hypothesis.

Besides the hypotheses already outlined there are many others, but enough has been said to indicate how varied and unlike are the suggestions now made by geologists, geophysicists and others to account for the surface features of the earth. Through it all we have recognized the fact that, whatever be the correct explanation, the earth's crust is in a state approaching isostatic equilibrium and that the departures from this state are due to factors local in character.

Among the most important weapons we have in the attack on the general problem are gravity measurements and seismic records. It is important, therefore, that a rapid field method be devised for ascertaining relative gravity values; that intensive work be done on the de-

velopment of seismographs which shall produce records relatively free from distortion and also that we learn better how to interpret the seismograph records themselves. Further work on the radioactivity of rocks is desirable.

In this brief review we have considered gravity, its measurement and that tendency toward gravity equilibrium in the figure of the earth that is expressed by the term isostasy. We find in nature everywhere a tendency or a striving toward equilibrium, which, however, is never attained because of the action of other forces. So it is with the phase rule when applied to the rocks; so it is with evolution; we find the approach toward equilibrium, but almost never the attainment of the goal. Always there are disturbing forces and ceaseless changes and shifts, never-ending activity in all phases of nature from the atoms themselves to the island universes. These departures from equilibrium are of special interest to the scientist; in isostasy they still await an entirely satisfactory explanation.

PHONOPHOTOGRAPHY IN THE MEASUREMENT OF THE EXPRESSION OF EMOTION IN MUSIC AND SPEECH

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I

THE field for psychological investigation herein outlined is defined by the statement that everything that the musician or speaker conveys to the listener is conveyed on the sound wave; we can intercept this sound wave with the camera and photograph it in as fine detail and on as enlarged scale as we desire, so that every characteristic of sound transmitted may be accounted for in terms of measurements on these sound waves.

To restate the point—ideas or meaning as conveyed in words; sentiment, emotion and impulse as voiced; instrumental music of all kinds—all that makes music or speech, as such, meaningful, beautiful or ugly is conveyed on the sound wave. The analysis and measurement of the sound wave furnishes full and adequate data for a scientific account of the facts. Thus modern phonophotography opens to us an enormous new field for investigation and for the laying of foundations for the science, the esthetics and the pedagogy of music and speech.

It offers us in particular a new approach to the psychophysics of the expression of emotion. In the psychophysics which was the making of modern psychology we controlled the stimulus; in this psychophysics we measure the output. Even the expression of emotion through music or speech may now be measured with fully as high degree of precision and with the same ease that we used to control the stimulus in the psychophysics of sensation.

The purpose of the present paper is not to discuss apparatus and methods of phonophotography, but rather to picture in high relief the scope and significance of the utilization of this method, drawing examples from our experiments up to date. The whole technique centers upon the recording of the sound wave on the principle of moving pictures and the reading and interpretation of such records for the solution of problems in the theoretical and the practical aspects of psychology and esthetics of music and speech.

When one considers the apparently infinite manifold of musical and spoken sounds, their meanings and their affective values, it is a great satisfaction to realize that all these may be reduced fundamentally to four measurable factors of the sound wave, *viz.*, *frequency*, or its reciprocal, *wave length*, which gives *pitch*, *amplitude* which gives *intensity*, *duration* which gives all the time values, and *form* which gives the tonal quality or *timbre*. Rhythm, consonance, harmony and volume are, of course, expressed in terms of combinations of these fundamental measures.

Let us illustrate in turn what may come from each of these four basic measures—*wave length*, *amplitude*, *duration* and *form*. Figure 1 is a sample of a section of a film recording a baritone voice. The smooth sine curve is a record of a tuning fork of 100 vibrations per second, which serves as a time line. The irregular curve is the record of the voice. The pitch of the tone at any moment is

enable us to deal with such phenomena as the following:

TABLE II

INTENSITY FACTORS IN A MUSICAL PHOTOGRAM
(IN TERMS OF AMPLITUDE OF
SOUND WAVE)

- I. Intensity (loudness): absolute, relative, uniform.
- II. Deviations from mean intensity:
 - (1) Erratic deviations of all kinds.
 - (2) Progressive deviations: crescendo, diminuendo, swell, circumflex, etc.
 - (3) Periodic deviations: vibrato, tremolo, innervation pulsations, all forms of accent or rhythmic stress.
 - (4) Attack and release.
 - (5) Forms of transition: voiced or non-voiced, silence.

In a similar manner we tease out from the record phenomena of *time*. There is a time line in units of .01 sec., as in Figure 1, which may be read in tenths of a unit, making thousandths of a second in terms of which the duration of any voiced phonetic element can be determined with accuracy.

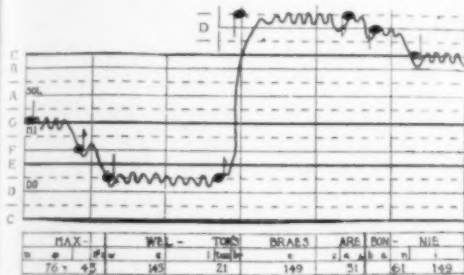


FIG. 3. *Annie Laurie* AS SUNG BY McCORMACK.
[FROM METFESSEL.]

Figure 3 is an example of the scientific musical staff which we have adopted to represent the combined pitch and time factors. Here the phonetic elements and the actual words are recorded on parallel lines. Above these are the demarcations of time for each syllable in a hundredth of a second. On the same legend are the demarcations of measures, phrases and one-second units. Tenths of a second are shown by the dashes and blanks on the

broken score lines. This scientific score then combines the essential pitch and time aspects of a song on a musical staff which will enable any musician to see and "hear out" the exact character of the musical performance in these two respects. Among the time factors that may be of musical significance are the following:

TABLE III

TIME FACTORS IN A MUSICAL PHOTOGRAM
(IN TERMS OF DURATION OF
VIBRATION)

- I. Mean time: absolute, relative, tempo.
- II. Deviations from mean time:
 - (1) Erratic deviations.
 - (2) Artistic deviations: accelerando, retardando, hold, staccato, legato, etc.
- III. All temporal aspects of rhythm.

Finally and most complicated of all are the data which come from the wave form and furnish the *timbre* or tonal quality. The significance of wave form may be shown effectively by a comparison of the wave form in two well-known instruments and a speaking voice. The middle curve in Figure 4 is the photograph of a tuning fork tone. It represents a pure tone; all other wave forms must be interpreted in terms of the relationship to that form. The top curve is a photograph of the sound wave from a trombone, rich as indicated by the complicated contour of each wave. The bottom curve shows sound waves from a speaking male voice.¹

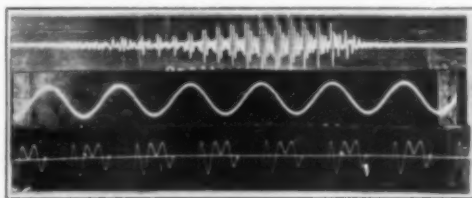


FIG. 4. WAVE FORMS ILLUSTRATING DIFFERENCE
IN TIMBRE OF TONE.

¹ These particular pictures were not taken for the purpose of harmonic analysis and are adequate only for pitch and time measurements.

These pictures impress the fact that one can see directly the character of a musical tone in the form of the sound wave. The human voice, both in singing and speaking, is just another instrument. The photographic reproduction of the sound has a far more faithful detail than even the most musical ear can hear and with the technique now available any form of sound wave may be analyzed into its component partials representing overtones or, if the partials are known, the wave may be reconstructed. In other words, we now have a relatively complete technique for the preservation and interpretation of tonal qualities. The best work that has been done on this subject within the last few years is in the scientific laboratories of the American Bell Telephone and the United States Bureau of Standards. Artistic and even unartistic expression of tone quality may be represented in the wave form so that we may reconstruct a tone, the wailings of a lute or a primitive language from this faithful representation of the sound medium.

The scope of application to timbre in music and speech may be exemplified by such features as the following:

TABLE IV

TIMBRE FACTORS IN THE MUSICAL PHOTOGRAM
(IN TERMS OF THE FORM OF THE
SOUND WAVE)

- I. Pure tone.
- II. All forms of noise and unorganized tone.
- III. Tonal clangs (harmonic analysis in terms of number, prominence and distribution of overtones) *e.g.*:
 - (1) Vowel and other voiced phonetic elements.
 - (2) "Character" of all voices and instruments.
 - (3) Artistic effects in tone quality.
 - (4) Faults in tone quality.
 - (5) Tonal fusion.
 - (6) Sonance.

This all sounds mechanical and oversimplified; but it is marvelously beautiful and useful that science can thus bring simple order and law to bear on

the understanding of our tonal manifold and the control of it. Frequency, amplitude, duration and form of the sound waves—these are the four kinds of material of which the whole structure is built. In terms of these the stupendous radio wonders in the transmission of sound have been produced. In terms of these the composer, the interpreter and the performer express music and speech. It is now only a matter of patient workmanship for the future inventor to make a synthetic human voice automation capable of speaking in languages, playing upon the whole gamut of emotions in vocal expression and even of executing artistic effects not yet attainable through the voluntary performance of the singing or speaking artist.

From this limitless field of possibilities thus opened let me present only two illustrations of the use of the photographographic method: the first, in the measurement of a specific type of expression of tender feeling; the second, the anthropological use of the method in collecting primitive music.

II

One of the most striking impressions one gets from the objective study of beautiful music is that art consists primarily in pleasing deviations from the regular. In music and speech pure tone, true pitch, exact intonation, perfect harmony, rigid rhythm, even touch and precise time play a relatively small rôle. They are mainly points of orientation for art and nature. The unlimited resources for vocal and instrumental art lie in artistic deviation from the pure, the true, the exact, the perfect, the rigid, the even and the precise. This deviation from the exact is, on the whole, the medium for the creation of the beautiful—for the conveying of emotion. That is the secret of the plasticity of art. The exact is cold, restricted and unemotional; and, however beautiful in itself, soon falls upon us.

One of the countless media for the expression of tender emotion by deviation from the regular in pitch and intensity in music and speech is a sort of quiver called the *vibrato*. In musical literature on theory and practice there is one baffling confusion as to the nature of the vibrato and its esthetic value. Several research men have recently worked on this problem in the Iowa laboratory. Volumes VIII, IX and X of the Iowa Studies in Psychology contain articles bearing on this subject. Dr. Metfessel, National Research Council Fellow in psychology, is now preparing an elaborate monograph, laying scientific foundations for the determination of the nature and function of the vibrato in terms of experimental data. He treats such topics as the determination and classification of types of the vibrato; causal relations in terms of mental, neural and muscular factors of control in the production of the vibrato; relative prevalence in trained and untrained singers—young and old, primitive and cultured; the difference between artificial and natural vibrato; its relation to other forms of periodicities; norms of beauty in its form; the significance of its emotional and automatic control; methods of acquiring, modulating, refining and inhibiting the vibrato; its relation to temperamental and other personal traits; its relation to the various qualities of emotion; and many other psychological, musical, anthropological and educational problems involved in this medium for the expression of tender emotion. Each issue is dealt with by rigid objective methods of laboratory procedure.

Dr. Schoen was the first to analyze and measure the vibrato. On the basis of measurements on the recorded singing of Aldah, Destinn, Eames, Gluck and Melba he demonstrated that the vibrato is a synchronous oscillation of pitch and

intensity of tone at the rate of about six vibrations per second. He measured separately the pitch and the intensity factors and found them to synchronize. While there is an error in his first measurements of pitch, this putting of the vibrato in black and white with mathematical precision should mark an epoch in musical theory and practice on this subject.

Generalizing from a vast variety of concrete data at hand we may define the vibrato in calm and beautiful singing as a synchronous pitch and intensity oscillation, ordinarily at the rate of from five to eight oscillations per second, in which perhaps the most beautiful effect is obtained when the pitch oscillation does not exceed one fourth of a tone and the intensity oscillation is as barely perceptible as the pitch oscillation and both take the form of a smooth sine curve.

Countless descriptive features may be added to such a definition for specific purposes, and qualifications may be added as new information accrues. The point is that we are now enabled to define, describe, measure and control such a subtle aspect of the expression of tender emotion as the slightest change in the character of a vibrato. The fundamental facts of the vibrato may be represented symbolically, as in Figure 5, which indicates that in good calm singing there is a synchronous and graceful oscillation in pitch and intensity of the tone as stated in the definition.



FIG. 5. A SCHEMATIC REPRESENTATION OF THE VIBRATO.

Dr. Kwalwasser, studying a large number of cases by the photographic method, found the vibrato present in 93 per cent. of his samples of cases in

well and moderately trained singers and 27 per cent. in untrained adults. He found that the vibrato is ordinarily parallel (that is, when the pitch rises the sound increases in intensity, as in Figure 5); but all gradations from this to the opposite vibrato, which is the reverse of the parallel, may occur. He also found cases of a pure pitch vibrato and of a pure intensity vibrato. His studies centered about the effect of placement, voice quality, pitch register, voluntary control and the development of the vibrato in children.

Dr. Simon refined the technique of measurement and determined the degree of reliability in consecutive sound waves in voices and instruments, an item which it is necessary to know in establishing periodicities in musical tone—an excellent example of the mastery of fine details.

One of the problems is to set up norms for recognizing good singing involving the vibrato. Figure 3 is from Metfessel's publication of the singing of Annie Laurie, giving a sample of McCormack's singing. (The entire song as rendered by McCormack and by Wells has been published.) An adequate collection of actual renditions of this kind will be the basis for determining what we may call good practice, which is the first step in the effort to determine a large number of component factors that operate to make the thing beautiful. The briefest illustration of this kind is shown in Figure 6. These samples are transcriptions from photographs of phonograph records, the phonograph record being entirely satisfactory for the study of pitch. The pitch vibrato is shown for what was supposed the least emotional of the words in the song, "and" in the twelfth measure ("And 'twas there that Annie Laurie . . ."). In these graphs the vertical division of the staff is in terms of half tones and the horizontal

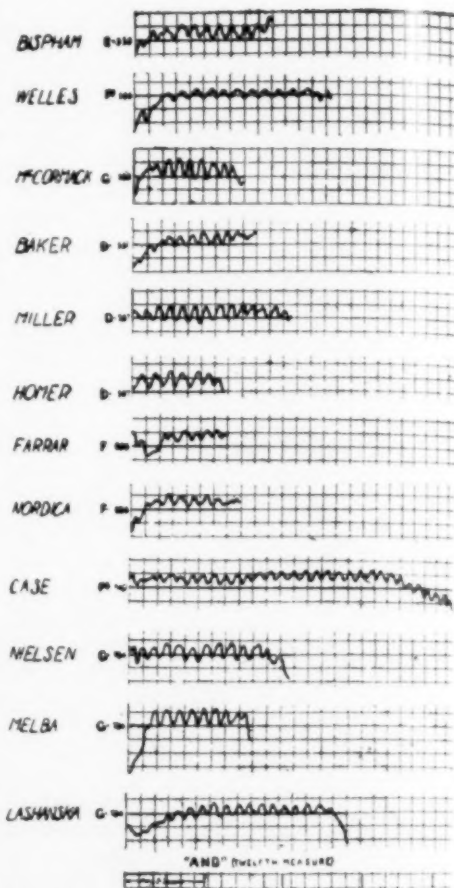


FIG. 6. THE VIBRATO OF TWELVE WELL-KNOWN SINGERS.

units in terms of tenth of a second. The graph shows exactly how each singer rendered this tone in pitch and duration. The vibration frequency indicated at the left shows what the true tone should have been for the prevailing pitch. The notes are not attacked or sustained in true pitch, but these again are often the plastic media for artistic effects and should not always be counted as wrong. Anna Case furnishes an illustration of artistic license in time in that she holds this note, which is within her favorite register and has a beautiful vibrato,

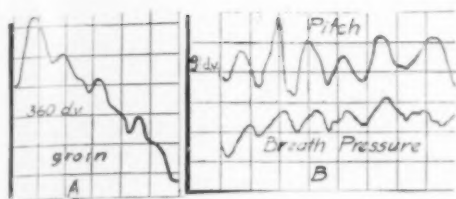


FIG. 7a. VIBRATO ON A FALLING INFLECTION.
FIG. 7b. VIBRATO ON A SUSTAINED PITCH IN SPEECH. [FROM GRAY.]

quite regardless of the time and tempo of the song. Each singer has an individual way of attacking, sustaining and releasing the note, but all have the vibrato. No one can hereafter say that it is really bad form at the present time to sing with a vibrato, unless he is willing to say that these twelve singers selected at random from good singers are in bad form. The intensity phase of the vibrato is not shown in these graphs, although it is present in every case and is perhaps fully as significant as the pitch oscillation.

We know nothing yet about the evolution and the heredity of this phenomenon, but are accumulating data in regard to its development in children. Dr. Metfessel now has records on the development of the vibrato in about three hundred cases of children ranging from five to eighteen years of age. These show that the vibrato may come in at different ages and under vastly different conditions, in different forms and at different rates.

Professor Wagner is attempting to analyze the different forms of the vibrato, particularly with reference to the teaching of the production of the vibrato and its modulation to conform to most natural methods of production and the most agreeable type. He takes a little child that has no vibrato and then trains with a specific theory in mind and records from time to time the artistic development and progressive automatization of that type. In all these and

various other studies now in progress the technique is comparatively simple and always objective.

Dr. Gray has studied the presence of the vibrato in emotion and speech and finds it quite prevalent. In speech it is not as conspicuous because words are spoken with rich inflection and are seldom sustained at any pitch level. He has, however, found that the vibrato frequently rides on a rising, falling, or circumflex inflection, as in Figure 7a. Figure 7b shows a speech vibrato in a sustained vowel sound. There are, however, other periodicities in speech sounds which are more important than the vibrato, for example, one at the rate of about twenty per second as shown by the contour of the curve in Figure 8, which is a record of breath pressure, probably synchronizing with intensity of tone, in singing.



FIG. 8. PERIODICITIES IN THE BREATH PRESSURE DURING THE SUSTAINING OF A TONE. [FROM METFESSEL.]

Dr. Travis, working with stutterers, has found examples of vibrato in their speech.

In addition to these objective measurements of the expression of the vibrato we must carry a variety of supplementary techniques for the purpose of determining the causes, conditions and relations to nervous disorders. Thus, the person singing with a vibrato is observed

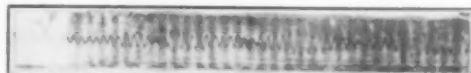


FIG. 9. PHOTOGRAPH OF THE ACTION CURRENT SHOWING THE RATE OF INNERVATION AND A PERIODICITY OF TWELVE CYCLES PER SECOND IN THE TONUS OF A MUSCLE. [FROM TRAVIS.]

some of our published records of singing and found that these oscillations show up in the details of a photogram of pitch. Figure 9 is a similar illustration of the effect of rate of innervation; this time through the measurement of action current which Dr. Travis is using in studying the tonus of muscles. Besides this basic periodicity there is evidence of other periodicities, some of much higher frequency and others of lower frequency, probably indicating interference in the innervation of cooperating musculatures. Here, as in the famous illustration of the growing blade of grass, if one had all the facts about the vibrato, he would have a wonderful knowledge of several sciences.

III

My personal interest in phonophotography dates from the time when the Smithsonian Institution sent its specialist in Indian music, Miss Frances Densmore, to our laboratory to have her ears certified with reference to the degree of reliability for the transcribing of phonograph records. It then occurred to me that it was possible to avoid depending upon the ear, which is quite inadequate for the purpose, and substitute a photographic method. This led to the developing of photographing of phonograph

records, and that in turn to the direct photographing from a musician's performance.

To demonstrate the availability of this method for anthropological field work, we have, in cooperation with the University of North Carolina, under a grant from the Laura Spelman Rockefeller Foundation, made a collection of Negro songs sung in the natural setting. Dr. Metfessel has prepared and is publishing a volume of these in the new musical terminology illustrated in Figure 10.

For the purposes of collecting, the camera is vastly superior to the phonograph in that it furnishes a permanent record, giving vastly finer details than can be heard from the phonograph, and is transcribable and measurable with a high degree of precision. Figure 11 is a picture of a Negro singing a spiritual after he had "warmed up" into ecstacy. His singing before that was very different. Such supplementary data are of anthropological value in preserving the atmosphere of the song. Indeed, the collector in the future will want not only the phonophotograph, but also some form of phonograph record and a moving picture of the musician in action, together with very accurate phonetic transcripts of words.



LORD LISTER

THE CENTENARY OF THE BIRTH OF LISTER, WHICH OCCURRED ON APRIL THE FIFTH, HAS BEEN CELEBRATED BY THE ROYAL COLLEGE OF SURGEONS AND AT WESTMINSTER ABBEY. IT IS SAID THAT LISTER'S DISCOVERY OF ANTISEPTIC SURGERY SAVED MORE LIVES THAN WERE LOST IN ALL THE WARS OF THE CENTURY SINCE HIS BIRTH.

THE PROGRESS OF SCIENCE

EDITED BY DR. EDWIN E. SLOSSON

Director of Science Service

LEGISLATION AGAINST THE TEACHING OF EVOLUTION

A SURVEY of the legislative season just ended discloses what appears to be an utter collapse, for the time being at least, of the drive to banish the teaching of evolution from American schools, widely heralded after the Dayton trial and the death of William Jennings Bryan. During the winter and spring of 1926-27 no less than twelve state legislatures had anti-evolution bills brought before them, and all twelve have adjourned without the passage of a single one of the measures.

In six of the states, California, Delaware, Minnesota, New Hampshire, North Carolina and North Dakota, the bills did not even get to the floor of the house, but were disposed of in committee, usually by decisive or even unanimous votes. In Missouri, which was declared in advance by the fundamentalist forces to be a pivotal state, the bill reached the house and was there rejected by the margin of 82 to 62. In West Virginia and Oklahoma anti-evolution measures were defeated by house votes of 57 to 36 and 46 to 30, respectively.

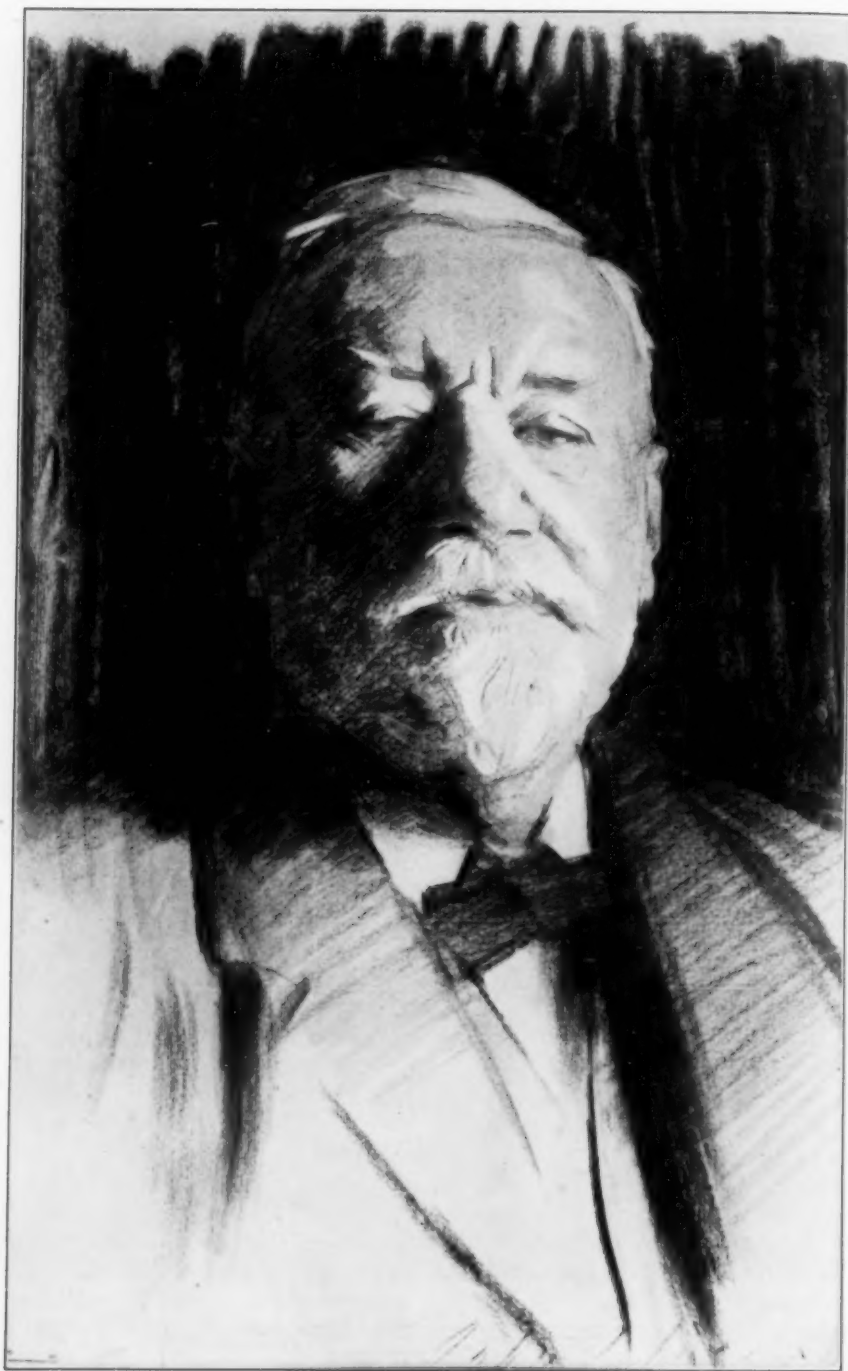
The fight was begun very early in Arkansas and carried on aggressively by the proponents of the bill, and it was expected that this state would pass over into the Tennessee-Mississippi class so far as freedom of teaching was concerned. But it turned out otherwise, for after passing the lower house by a very close margin (three votes, according to one report; one vote, according to another) it was rejected in the senate by an overwhelming aye-and-nay vote. A part of the clergy in Arkansas are reported to be very angry over the outcome of the contest, and to have declared war

on all members of the legislature who are known to have voted against the bill.

In only two states has the proposed repressive legislation survived even in an attenuated form. In Alabama, a bill on the Tennessee model was introduced during January and remained sleeping in committee until, in March, the legislature adjourned until June 7. What will happen then no one will undertake to prophesy. In South Carolina the bill likewise slept until the closing hours of the session, when it was reported out by the committee, without recommendation; in order, its author stated, that it might remain on the calendar until the next session.

The Florida legislature meets much later in the year than do the law-making bodies of the other states; it convened early in April. It is taken for granted that some one will introduce a bill at Tallahassee, but up to the present no anti-evolution proposal has appeared. Some years ago the legislature of this state went on record with a resolution condemning evolution, but this does not have the force of law, and is steadily ignored by teachers in Florida schools and colleges.

Even the two states that have enacted anti-evolution laws can hardly be counted as completely gained by the fundamentalist forces. In handing down its decision on the appeal of the Scopes case, the Tennessee State Supreme Court justices gave three distinct versions of their ideas of the meaning of the law, which are interpreted by competent authorities on constitutional law to mean that one can teach about anything he



CHARLES SPRAGUE SARGENT

IN WHOSE DEATH AMERICA LOSES ONE OF ITS LEADING MEN OF SCIENCE. DR. SARGENT WAS FOR FIFTY-FIVE YEARS DIRECTOR OF THE ARNOLD ARBORETUM AND FOR NEARLY AS LONG ARNOLD PROFESSOR OF ARBORICULTURE AT HARVARD UNIVERSITY. THE PORTRAIT IS FROM A DRAWING BY JOHN S. SARGENT.



WILLIAM HEALEY DALL

DISTINGUISHED FOR HIS WORK ON RECENT AND FOSSIL MOLLUSKS, WHO HAS DIED AT THE AGE OF EIGHTY-TWO YEARS. DR. DALL WAS CURATOR IN THE U. S. NATIONAL MUSEUM FOR FIFTY-EIGHT YEARS. IN THE DEATHS OF PROFESSOR SARGENT AND OF DR. DALL, AMERICA LOSES TWO VERY GREAT NATURALISTS SUCH AS IT IS NOT LIKELY AGAIN TO PRODUCE.



LAPLACE

THE GREAT FRENCH MATHEMATICIAN, THE CENTENARY OF WHOSE DEATH IS NOW BEING CELEBRATED AT ALMOST THE SAME TIME AS THE TWO HUNDREDTH ANNIVERSARY OF THE DEATH OF NEWTON. LAPLACE'S "MECHANIQUE CELESTE" IS THE MOST NOTABLE SUCCESSOR OF NEWTON'S "PRINCIPIA." HIS NEBULAR HYPOTHESIS WAS PROPOSED IN HIS "SYSTEME DU MOND," PUBLISHED IN 1796. THE PORTRAIT IS FROM AN ENGRAVING AFTER A PAINTING BY NEGEON.

pleases in Tennessee so long as he does not come out flat-footed for atheism or philosophic materialism. In Mississippi the law is in force, but has not yet been tested in the courts.

Action by the Education Association of the Methodist Episcopal Church of the South, in condemning the anti-evolution legislative program, was hailed as highly significant by educators and interested persons everywhere. The resolution was introduced by the president of Duke University, and only two delegates voted against it. Prominent Southern Baptist churchmen have also gone on record as opposed to legislative restrictions on teaching.

Checked in their program of stopping the teaching of modern science by legislative action, the fundamentalists have adopted a new program, which may become the more formidable because it is so widely diffused and because it deliberately appeals to the willingness of certain types of persons to play the spy and informer. The "Supreme Kingdom," founded by Edward Young Clark, formerly prominent in Ku Klux Klan circles, announces as part of its plan to operate through small local organizations, endeavoring to prevent the employment of teachers who believe in evolution and to prevent the election of school officials who will hire or back them.

THE ANTIQUITY OF MAN IN AMERICA

PRIMITIVE man lived in America at a vastly earlier time than is believed by most scientific men if the evidence gathered by J. D. Figgins and Harold J. Cook, of the Colorado Museum of Natural History, is valid.

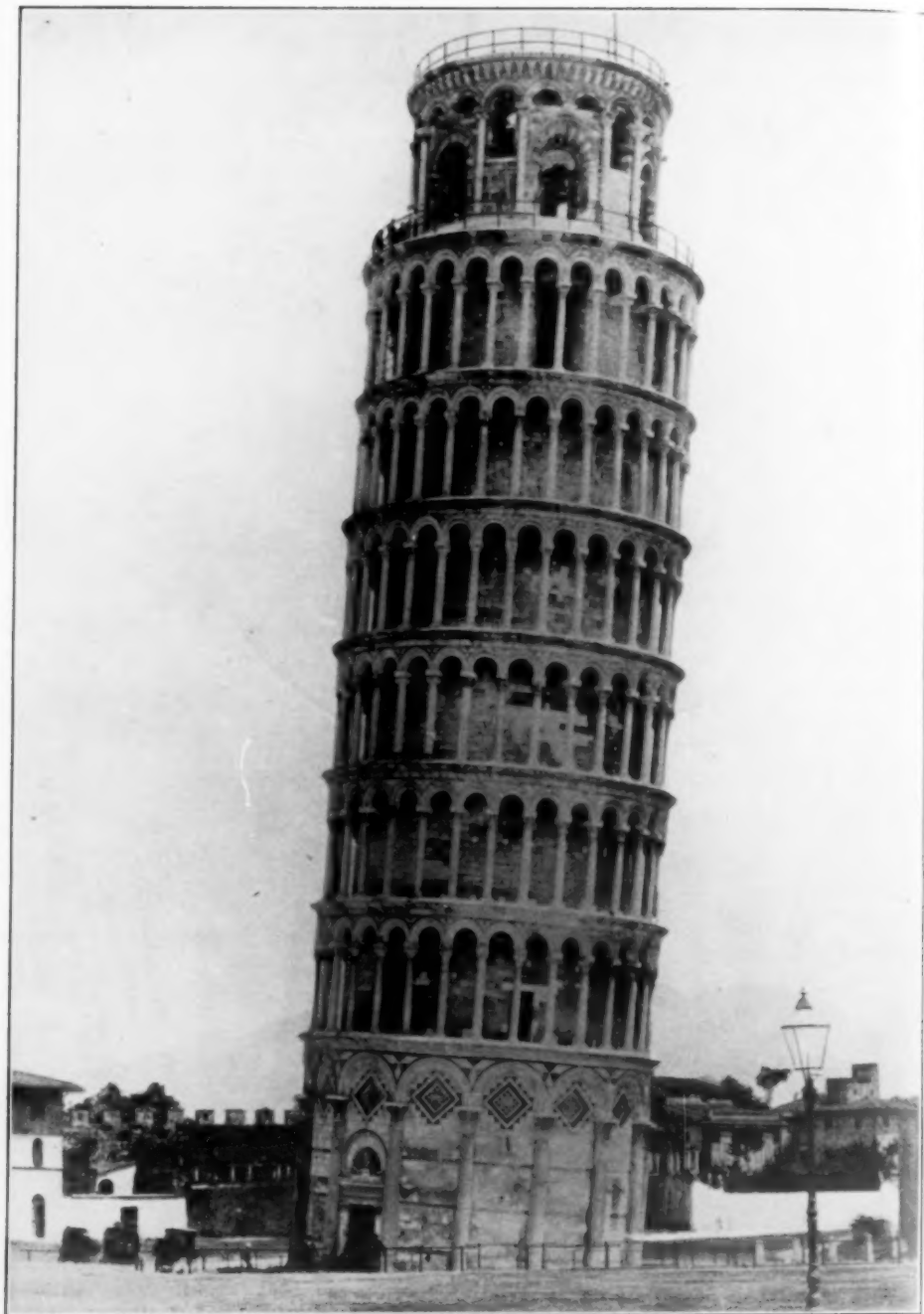
Instead of dating back only some 8,000 to 25,000 years, the time when most archeologists and anthropologists say the Indian came to America from Asia, these human relics, because of their association with extinct animals and geological deposits of known antiquity, are assigned to the geological period that scientists know as the Pleistocene. That was the time of the great Ice Age when northeastern America was periodically covered with an immense glacier and when prehistoric elephants and mastodons roamed the land. It was from 25,000 to a million years ago.

From three localities have evidences of human antiquity on the American continent been obtained: Frederick, Tillman County, Okla.; Colorado, Mitchell County, Texas, and Folsom, Union County, New Mexico. Investigations at the site of the Oklahoma discovery have

just been completed and the findings have not yet been announced.

From all three sites, arrowheads have been unearthed in close association with extinct animals. Along Lone Wolf Creek, near the town of Colorado, Texas, flood waters exposed the bones of an extinct species of bison, and while large blocks of the earth in which they were embedded were being removed for transportation to the museum, three arrowheads, totally unlike those in any known collections, were found beneath a nearly complete skeleton. The arrowheads were of grayish flint, thin and not notched.

At Folsom, New Mexico, fossil bones were discovered at the extraordinary altitude of 7,000 feet, and among the fossil bones were found two arrowheads similar to those found in Colorado. The bones were identified as those of three hitherto unknown and extinct species of bison and an ancient deer-like animal. Discovery of this deposit was made through the interest and observation of Fred Howarth and Carl Schwachheim. An exact geological determination of the



THE LEANING TOWER OF PISA

THE CAMPANILE OF THE CATHEDRAL OF PISA IS ONE OF THE FINEST EXAMPLES OF ROMANESQUE ARCHITECTURE; BUT IT IS BEST KNOWN FOR ITS LEANING POSITION. IT WAS FIFTEEN AND A HALF FEET OUT OF THE PERPENDICULAR IN 1829, AND THE DEPARTURE IS NOW ABOUT A FOOT GREATER. THE FOUNDATIONS ARE NOT MORE THAN TEN FEET DEEP, AND THEIR CIRCUMFERENCE IS ONLY THAT OF THE TOWER. IT IS THOUGHT THAT THE TOWER ASSUMED ITS OBLIQUE POSITION WHILE IT WAS BEING BUILT. ITALIAN ENGINEERS ARE NOW CONSTRUCTING A CEMENT SOCKET UNDER THE TOWER TO PREVENT FURTHER SINKING.

age of the deposit has not been made, but it is believed to be late Pleistocene.

The locality richest in evidences of ancient man in America is near Fredrick, Oklahoma. F. G. Priestly read an article by Mr. Cook, calling attention to the possibility of ancient man having existed in America. He realized that arrowheads and stone-grinding implements that were being uncovered from time to time by steam shovels in a sand and gravel pit might be of some interest. With the cooperation of A. H. Hollman, owner of the gravel pit, he reported the discovery to Mr. Cook, who, with Mr. Figgins, promptly investigated. There they found three distinct layers of deposits and in a very short time two arrowheads and some seven metates, primitive grinding instruments, were excavated from the pit. Those working in the pit remembered other worked stones that had, before realization of their significance, been thrown away. With the

artifacts, as in the other cases, remains of extinct animals were found, and eight feet above the level at which the grinding stones nearest the surface were discovered, there were found remains of the mammoth, including numerous teeth. This is considered strong evidence of the great antiquity of the arrowheads and the metates. A representative of the Colorado Museum of Natural History is now located at the gravel pit to collect and preserve any other such finds.

Inspection of the arrowheads discovered shows them to be primitive, and yet the man who made them must have progressed considerably in culture, according to Mr. Figgins. Mr. Cook has made a careful study of the geology of the three places where discoveries were made and he has expressed himself as "convinced of contemporaneous association" of the artifacts with Pleistocene deposits and animal remains "surprising as such a culture at that time may seem."

ADVANCES IN TELEVISION

DESCRIBED as one of the greatest triumphs in the history of methods of communication, the television process of the American Telephone and Telegraph Company, first exhibited in action between New York and Washington on April 7, is the product of many minds working together in the Bell Laboratories in New York under the guidance of Dr. Herbert E. Ives. Despite the elaborateness of the apparatus, television depends essentially upon the fact that a film of potassium metal in a vacuum tube can be made to give a small electric current when light shines on it. This is the photoelectric cell.

In previous methods, the subject, whose visage is to be transmitted, is flooded with brilliant light, and a lens picks up the illumination and focuses it on a small photoelectric cell. In the new method, by the idea of Dr. Frank Gray,

the subject is illuminated with a tiny moving spot of light, which is picked up by a battery of large photoelectric cells—the largest yet made. The result is the most successful transmission of the actual view of the human face that has yet been achieved.

As seen on the small receiving screen, the scene looks like a halftone two inches high, printed in the pink sheet edition of a daily paper—except that it has come to life. Most newspapers print photographs in what is known as halftone—small dots spaced 50 to 60 to the inch and blended by the eye into a continuous picture, a process, incidentally, which was the invention many years ago of Frederic E. Ives, the father of Herbert E. Ives, who is immediately responsible for the new process.

In the television receiver, the picture is also made up of fifty eye-blended rows

of light and dark, which appear pink because the light in which they are painted comes from glowing neon gas—a rare element found in the atmosphere. When two metallic electrodes are sealed into a glass tube from which all air has been exhausted, but which contains a little neon, and an electric current is passed through, the gas glows with a pinkish light. Unlike the ordinary electric lamp with a filament of tungsten, which continues to glow for an instant after the current has been disconnected, the neon light goes on and off as instantaneously as the current itself.

To television a speaker's face from Washington to New York, for example, the light starts from the carbons of an automatic arc lamp. In front of the lamp is a disc with fifty holes around its edge in a spiral, each hole a little nearer the center than the one before it. A lens projects an image of the holes out into space, just as the lens of a movie machine projects an image of the moving film on to the screen, but in the television device the screen is the subject's face. And just as the movie film travels through the machine so fast that the single pictures are not seen, but are combined together by the eye into a continuous picture, so does the rapidly moving disc, containing the holes, move so rapidly that the fifty holes, each one a little lower than the one before it, sweep across the facial screen in less than a fifteenth of a second.

Outside the light from the arc, shining through the holes in the disc, the subject is in semi-darkness. In front of him are three photoelectric cells, the eyes of television. They turn the light into electricity. The production of these cells itself is a triumph, accomplished by Dr. Ives. They are the largest that have yet been constructed. When the moving finger of light, a fiftieth of an inch in diameter, sweeps across the face, it encounters the light-colored flesh; light is reflected to the sensitive photoelectric

cells. By means of amplifiers like those used in radio stations, the photoelectric cells' tiny current, the electrical counterpart of the light, is magnified thousands of times. And when the spot of light reaches a dark part of the face—the pupil of the eye perhaps—and no light is reflected, no current flows from the cells to the amplifiers.

Thus, the lights and shades of the face are transformed into a varying electric current, just as the ordinary telephone transmitter transforms the sounds of the voice into a pulsating current. It travels over the telephone lines for hundreds or thousands of miles, or else on the radio carrier waves for even greater distances. The receiving end picks up the current, amplifies it some more to make up for any losses in transmission, and connects it to the receiver, with its neon tube.

The variations in current are translated by the neon tube back into variations of light. But the tube shows an extended surface of light—an inch or more square—with no semblance of a picture of a face or anything else. Here the revolving disc again plays a part. A disc the exact duplicate of the one at the sending end revolves in front of the neon tube.

If the spot of light in the sending apparatus is shining on the bright flesh, the receiving screen shows a corresponding bright area through the hole. And then as the sending light spot moves to the dark pupil of the eye of the subject, the neon ceases glowing and the screen shows a dark spot. As the spot moves to another white portion, such as the bridge of the nose, the neon again shines through the hole, which has also moved. The receiving disc, like the transmitting one, moves so rapidly that the light appears to the person observing as a continuous surface, blended into a motion picture of the sending scene.